AUTOMOBILE ENGINEER

DESIGN · PRODUCTION · MATERIALS

Vol. 45 No. 13 DECEMBER 1955 PRICE: 3s. 6d.

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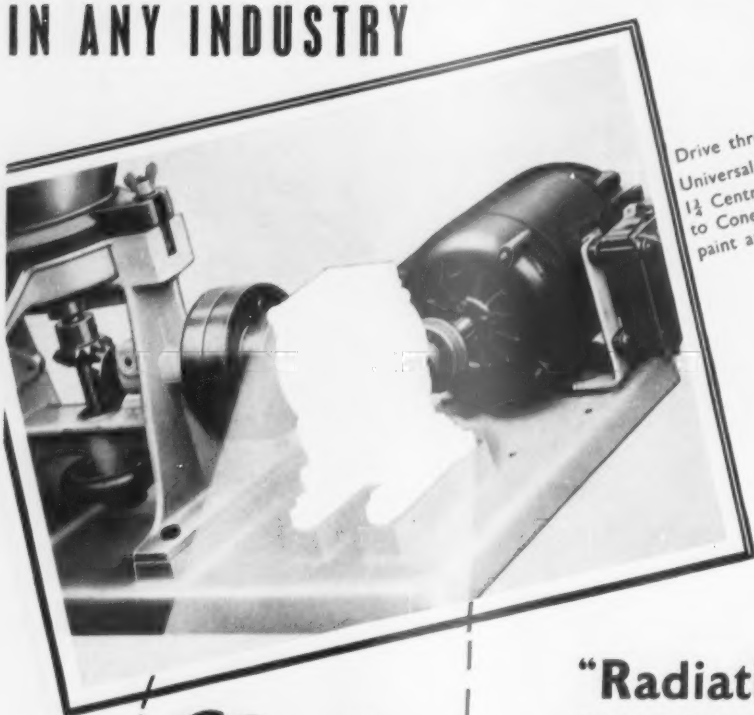

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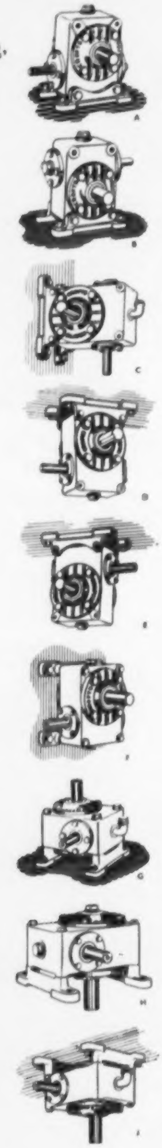

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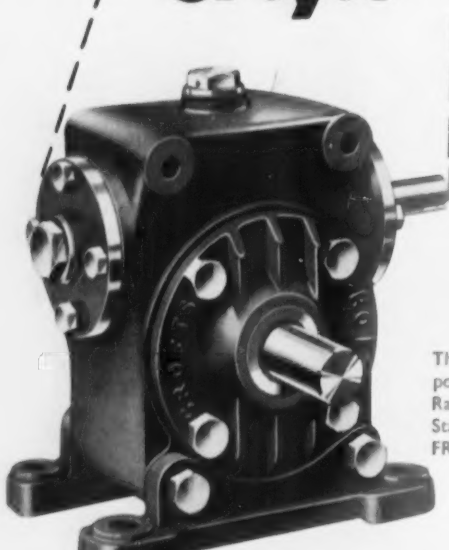

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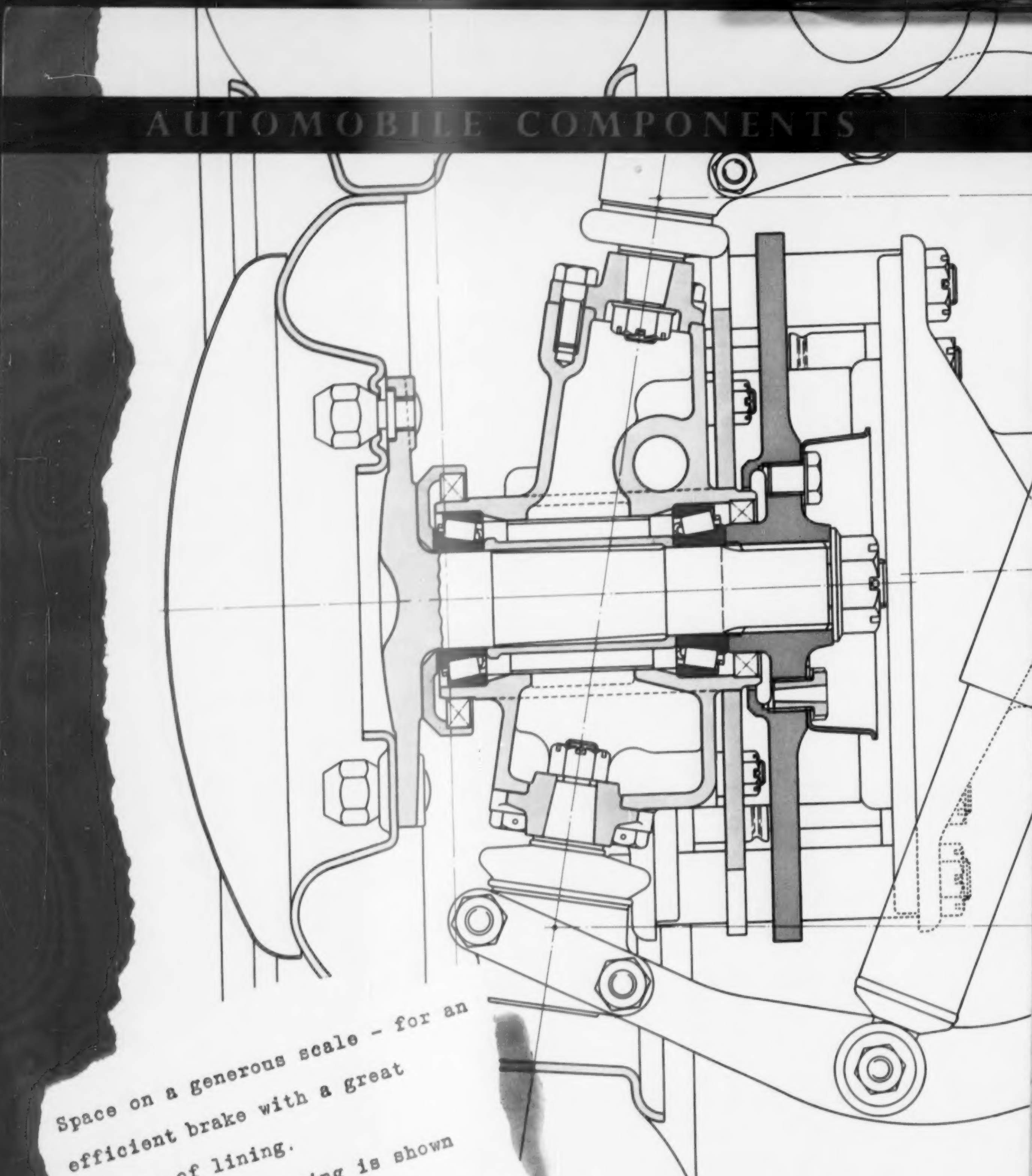

Space on a generous scale - for an efficient brake with a great reserve of lining.
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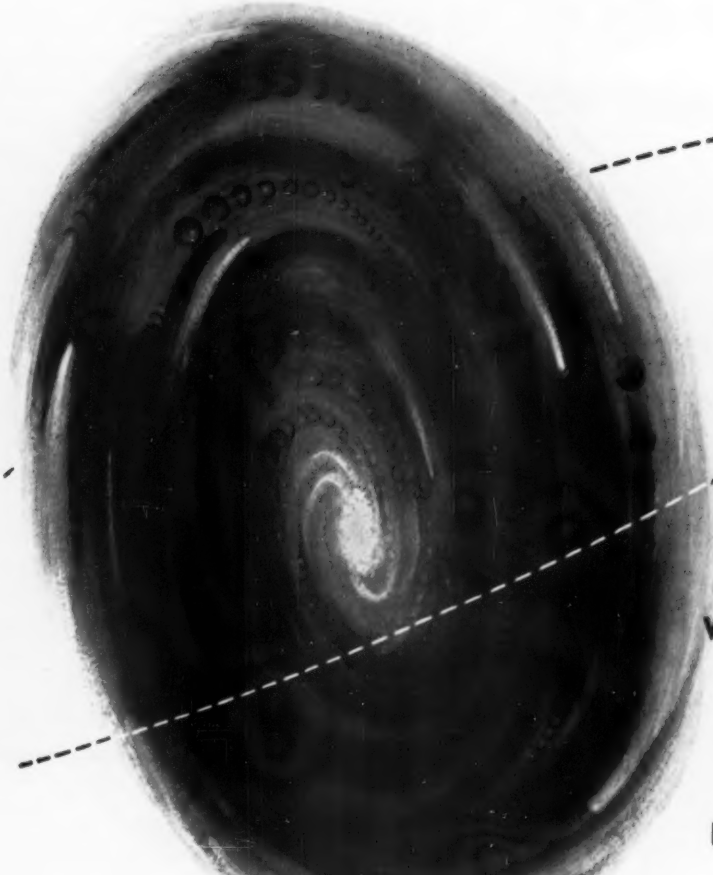

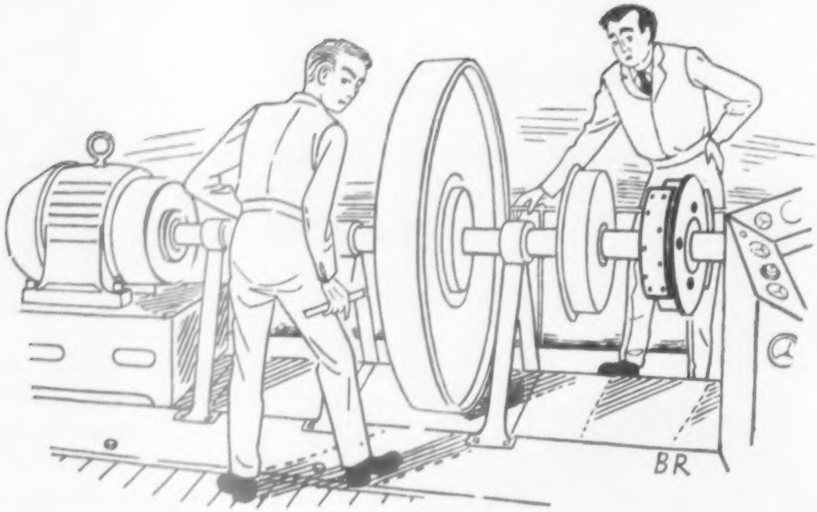

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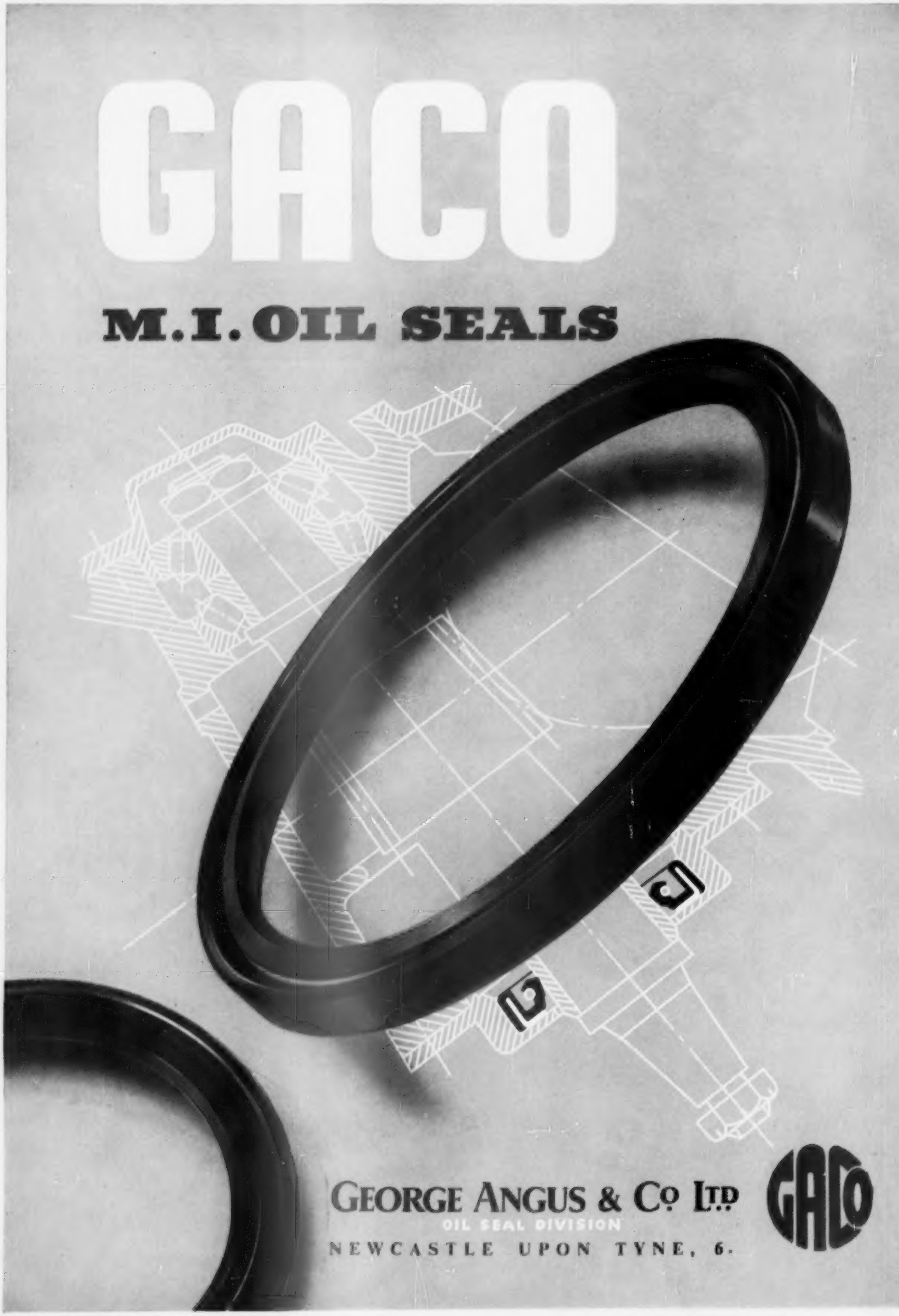
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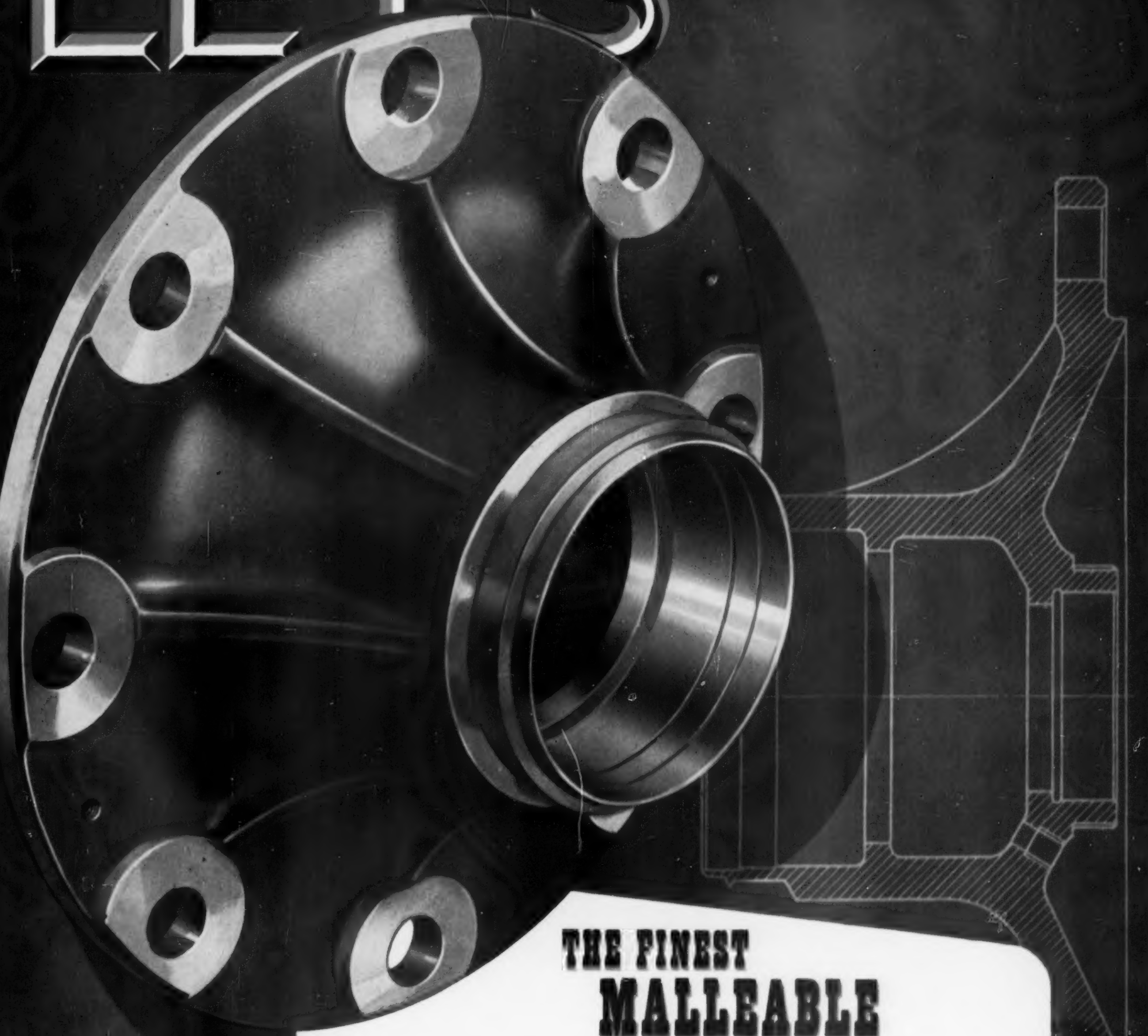

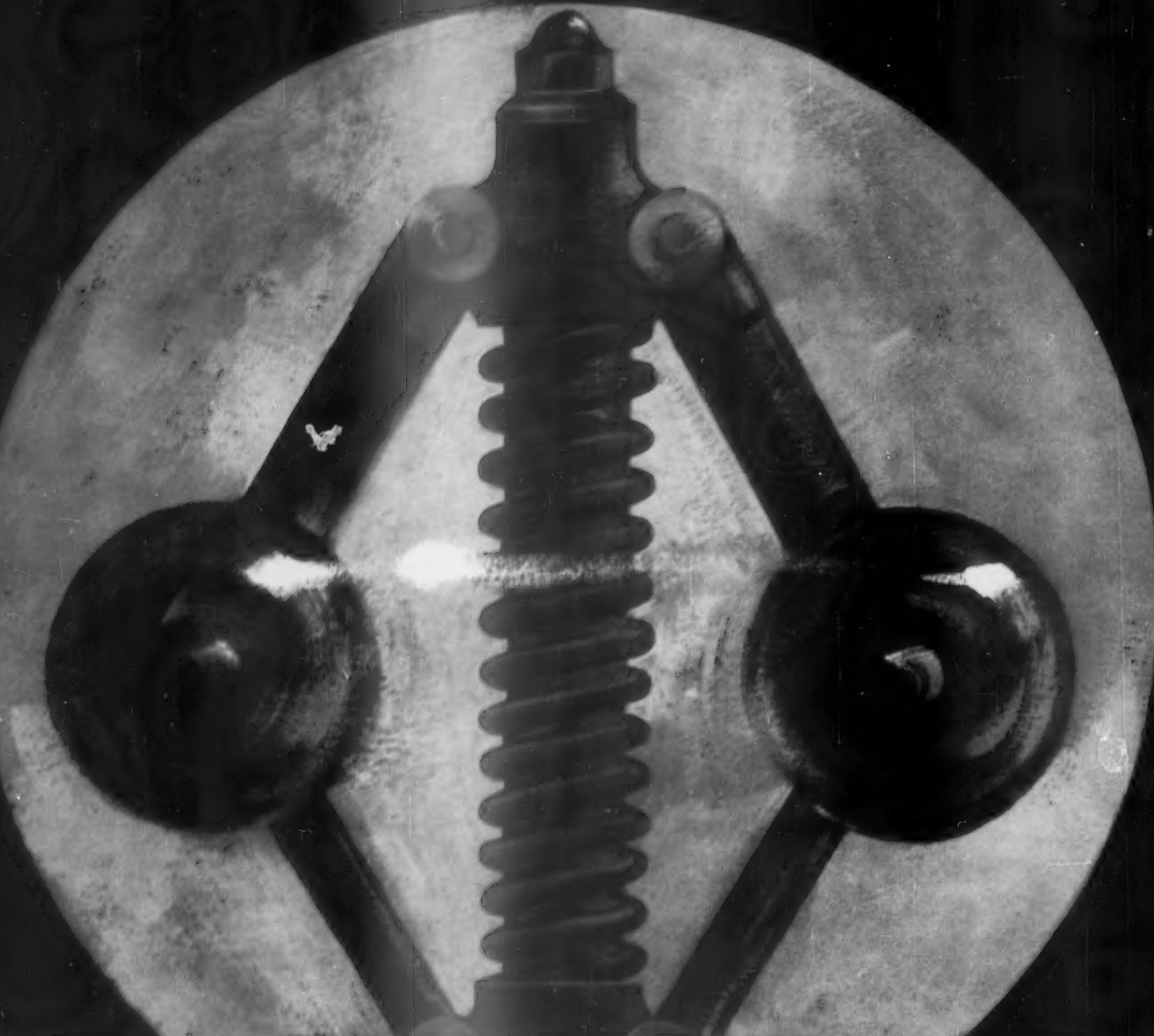

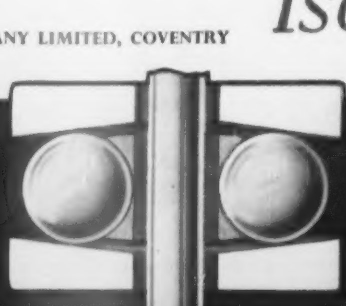

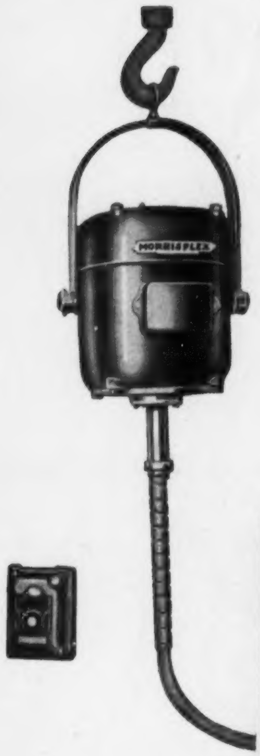

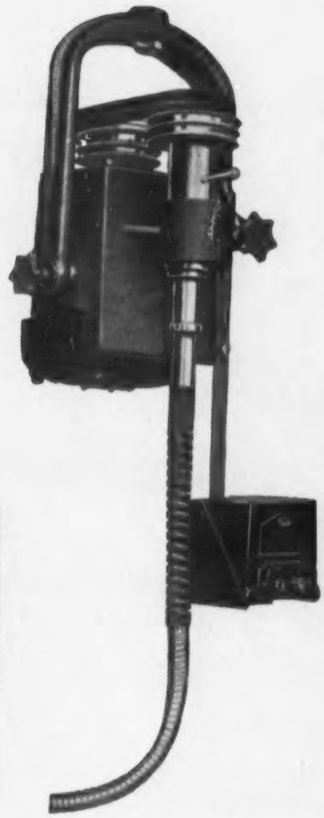

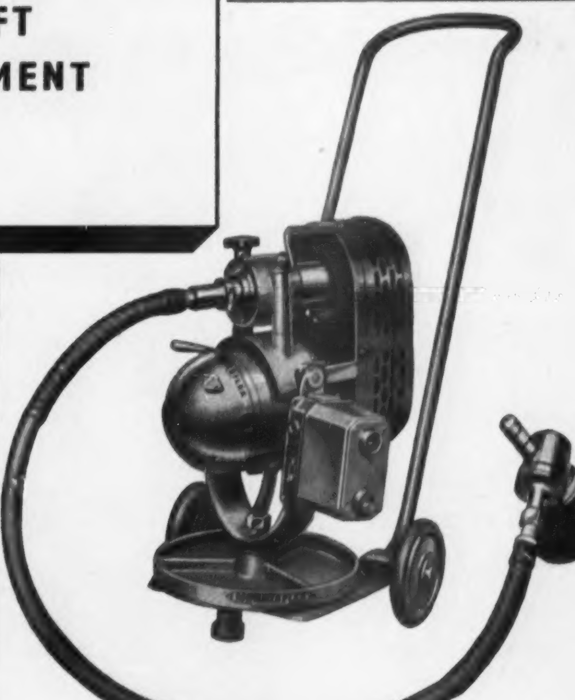

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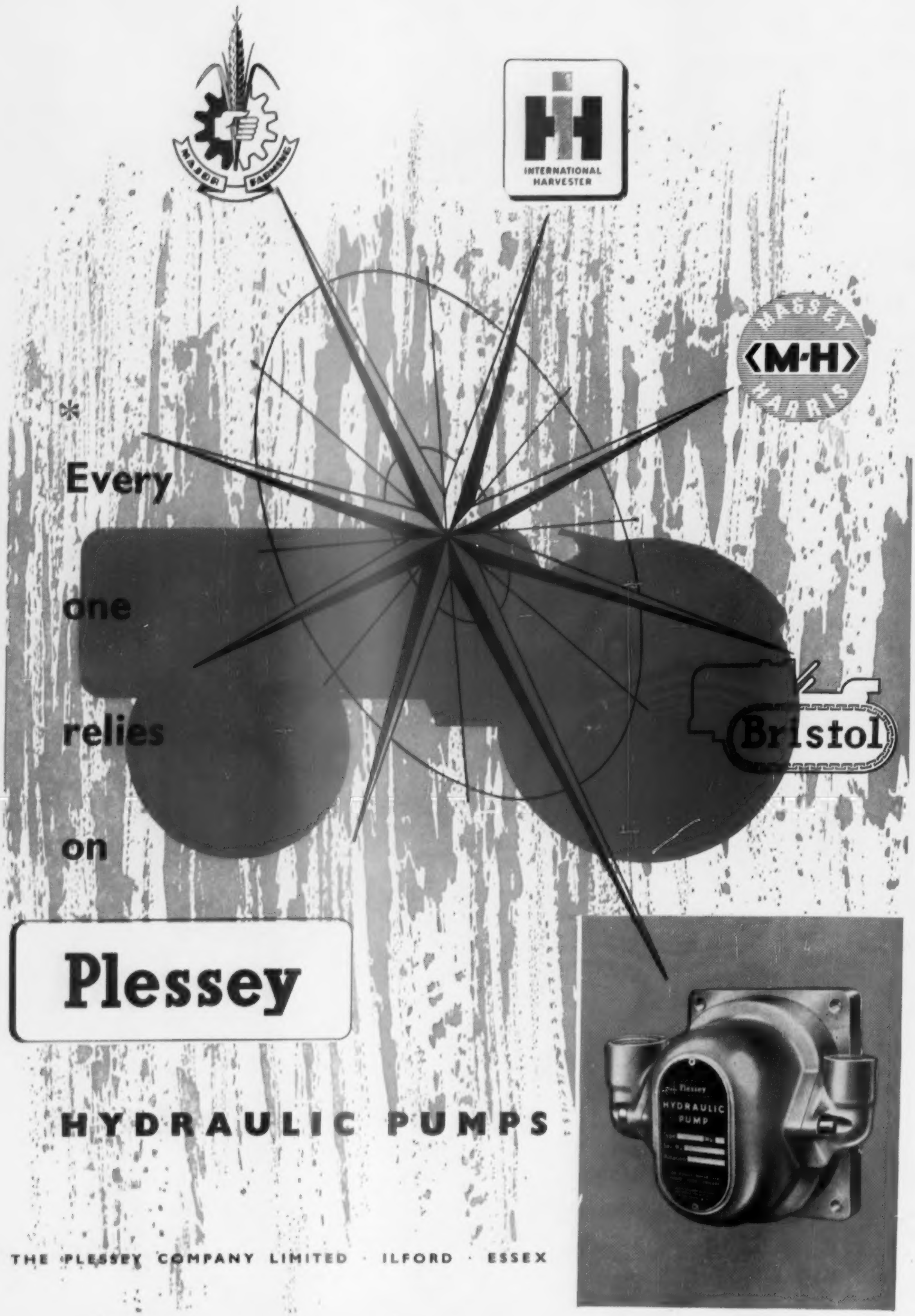
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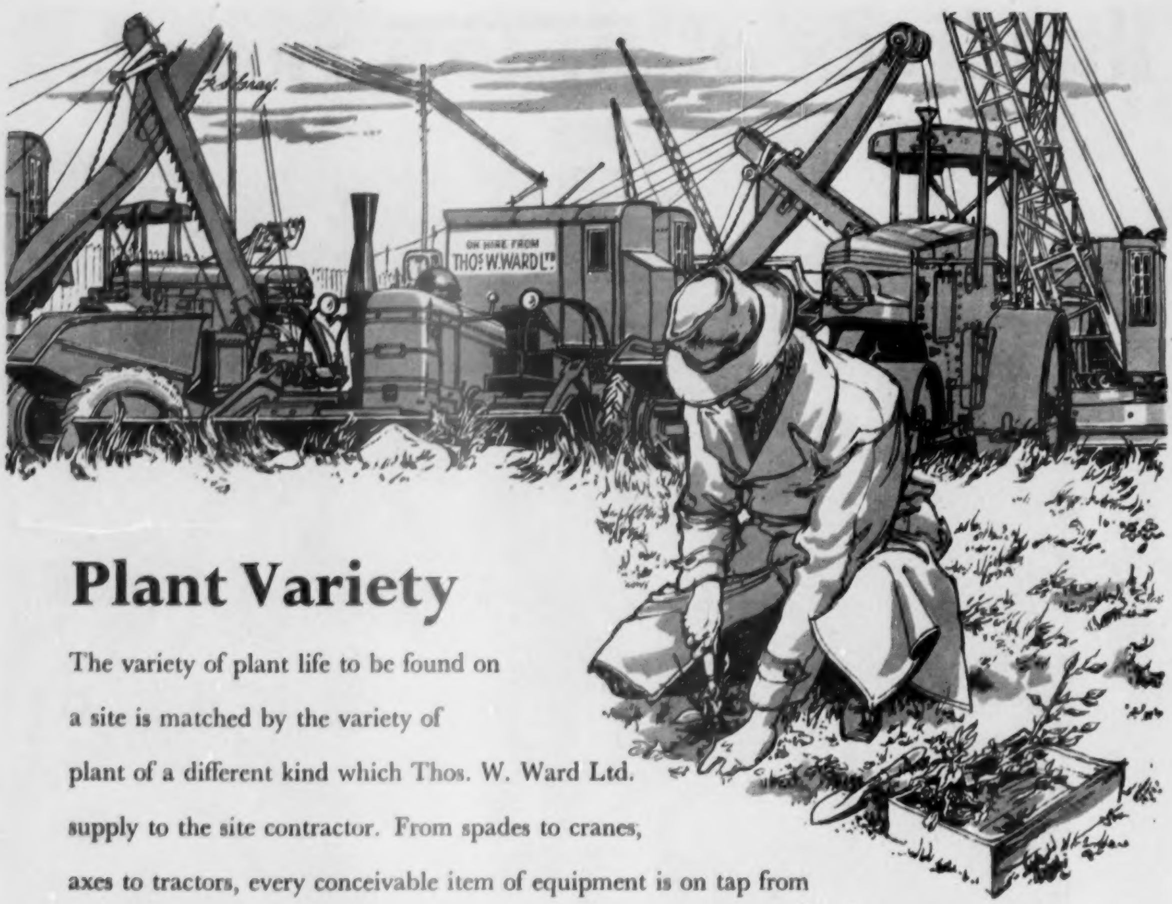
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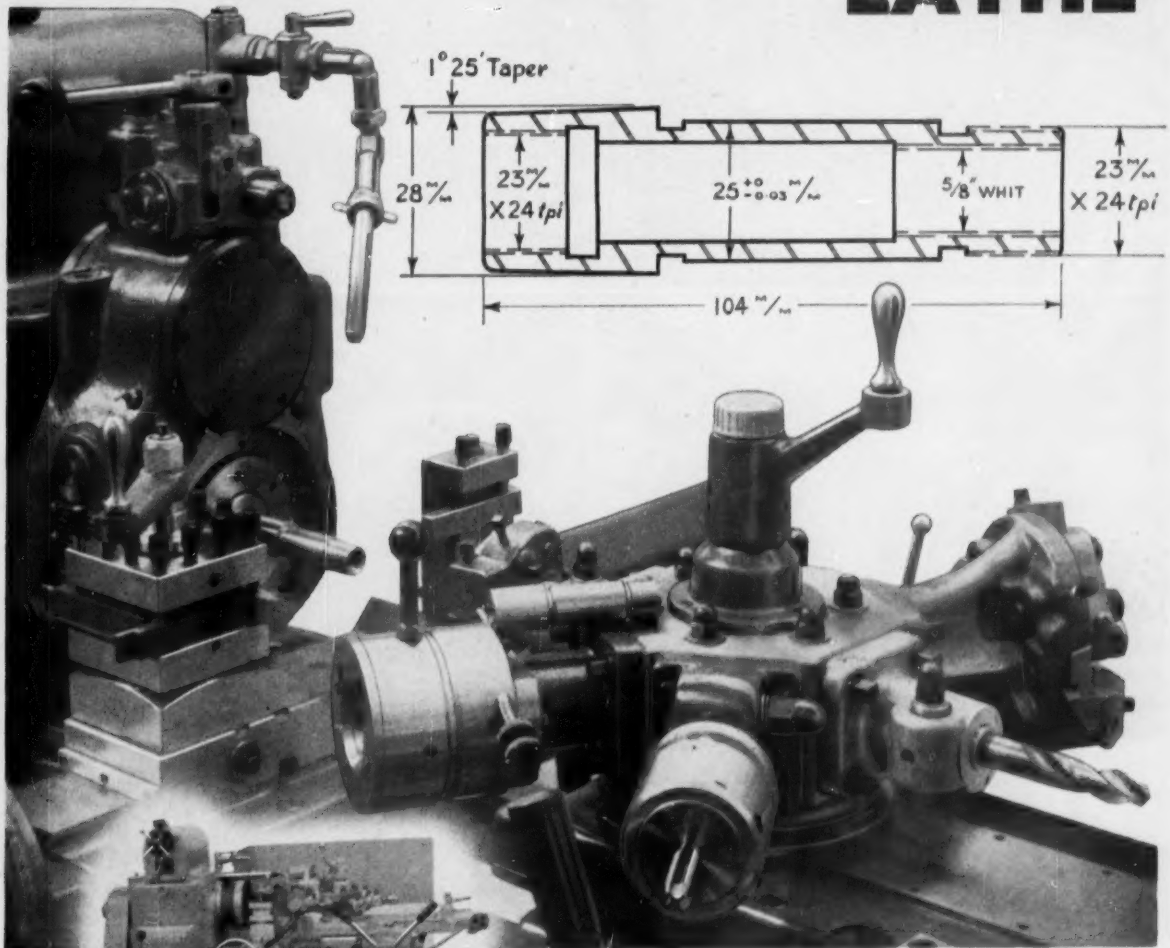
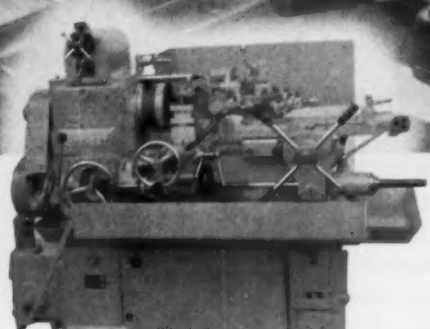


Tooling on a Herbert No. 2D Capstan Lathe, with air-operated dead-length bar chuck for machining, from 35-tons tensile steel bar, the component shown, in 8 minutes—two operations.



Swing	9"
Draw-in chuck admits ...	1¼"
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Working stroke of capstan ...	6"
Spindle flange to capstan, max.	18¾"

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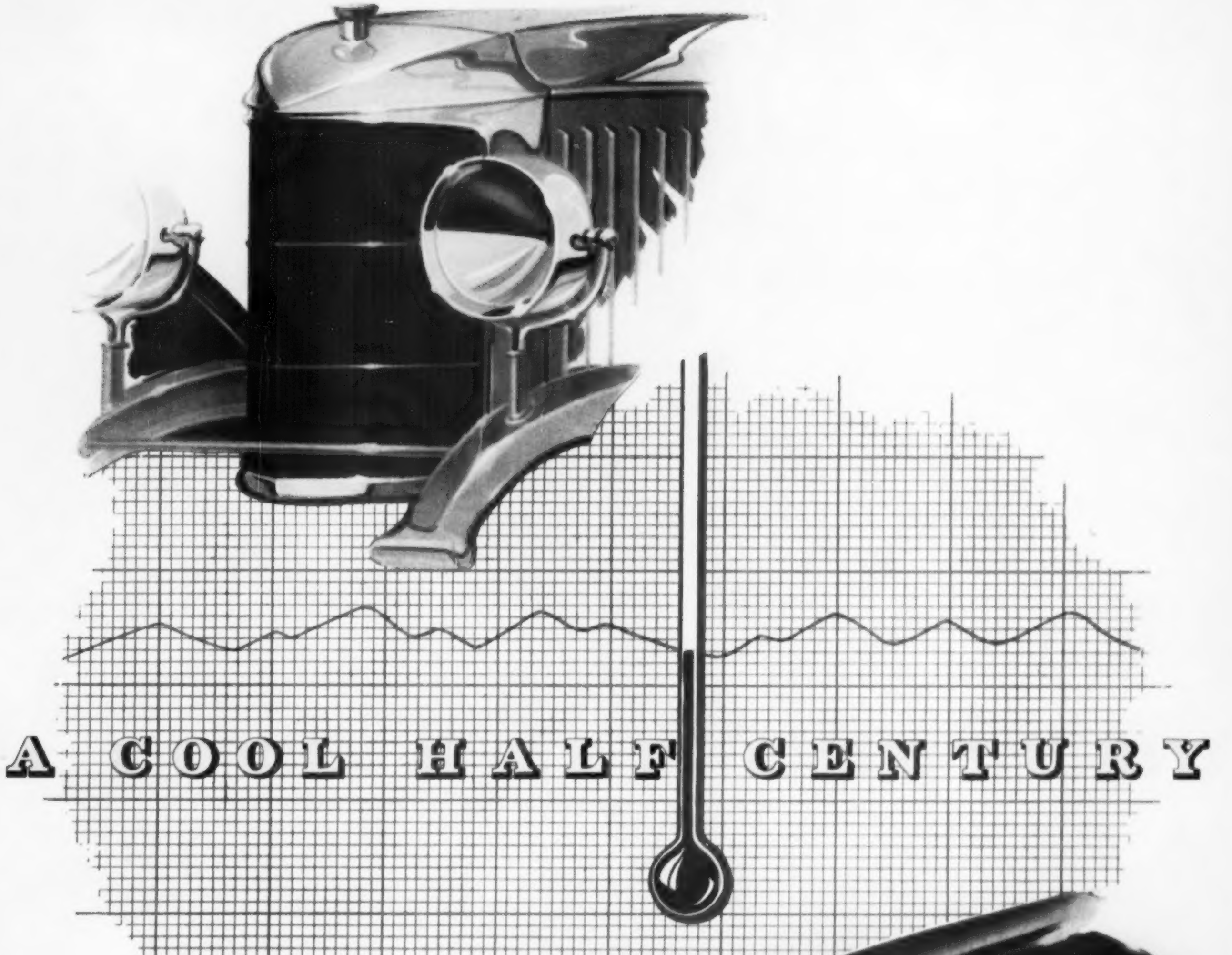
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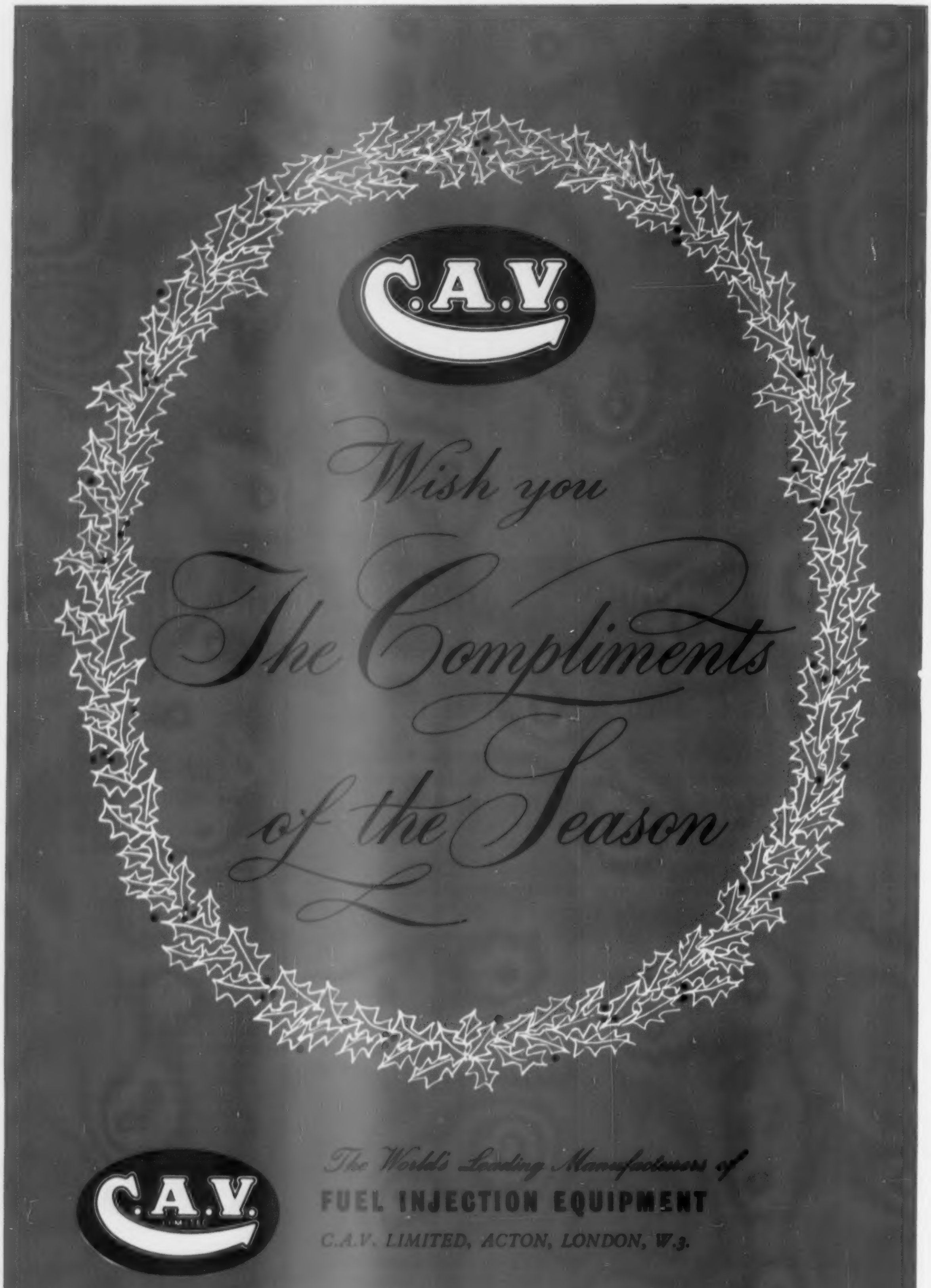
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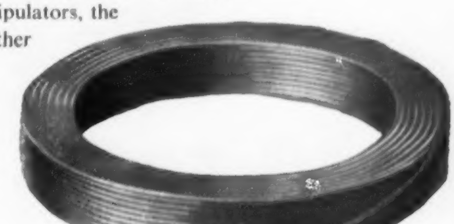

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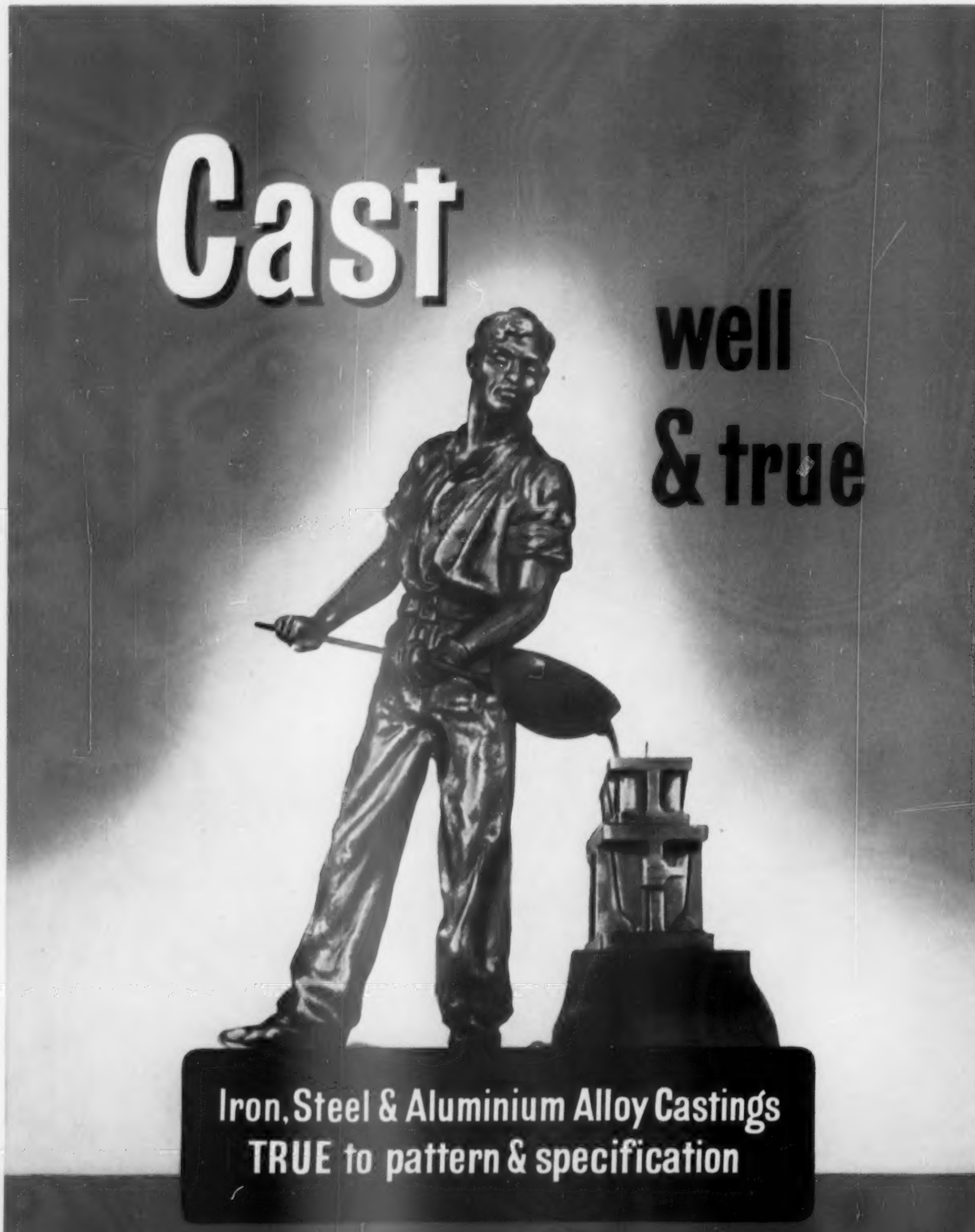
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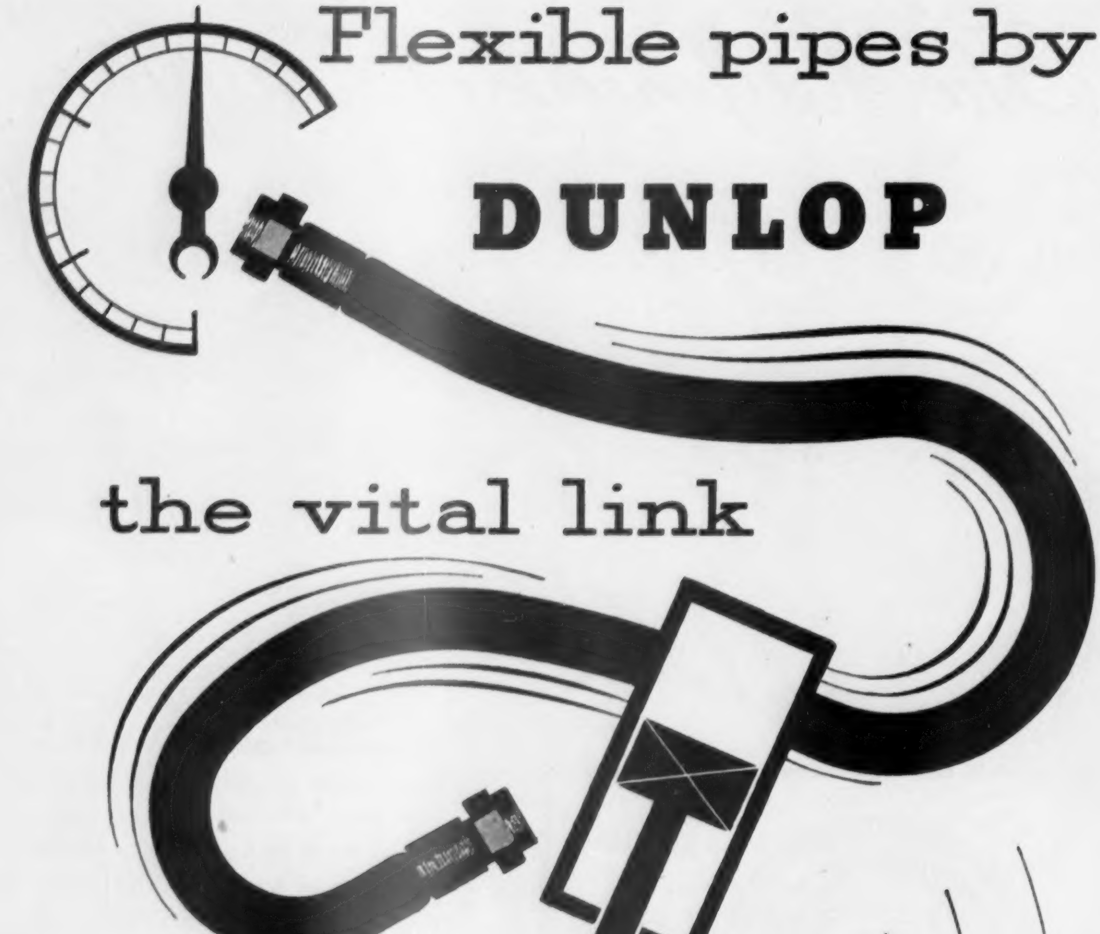
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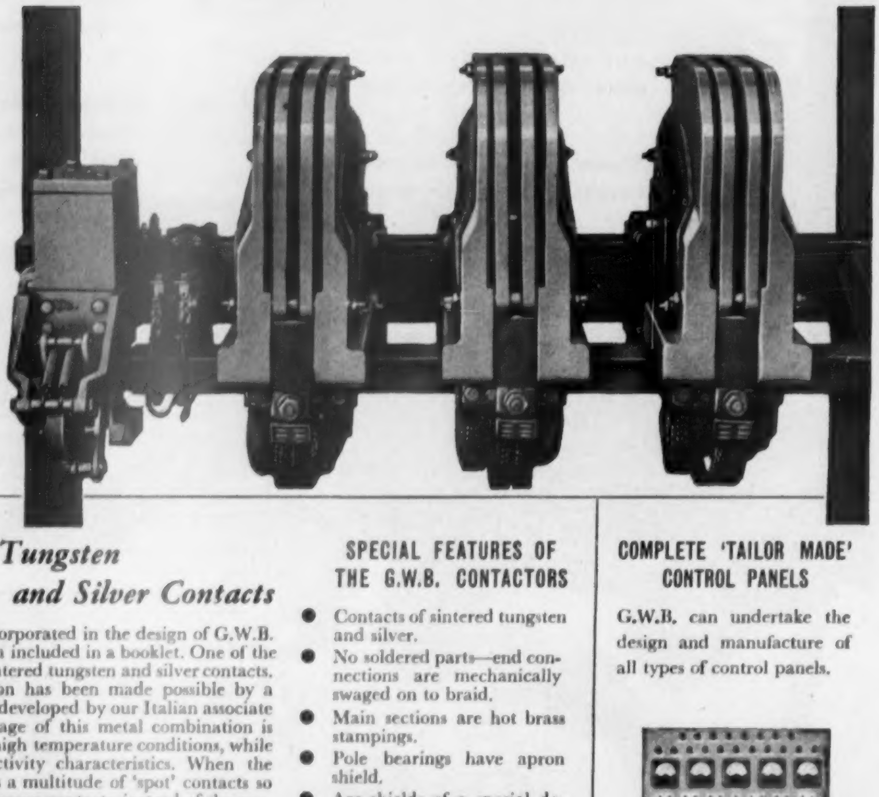

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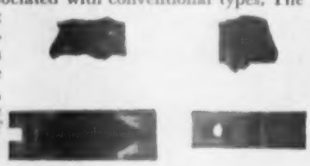

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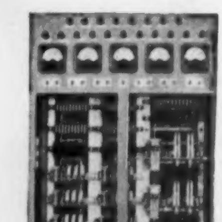

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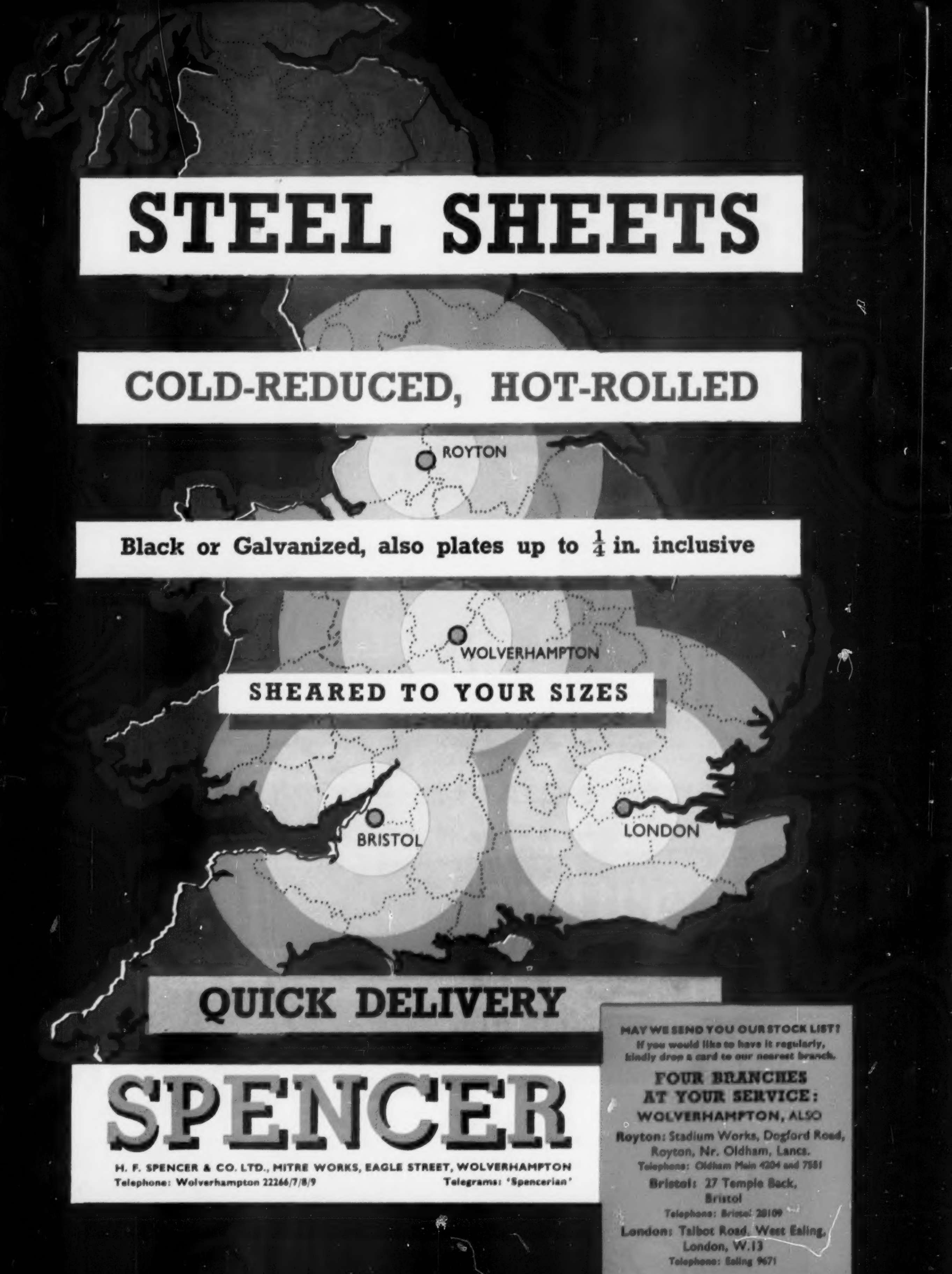
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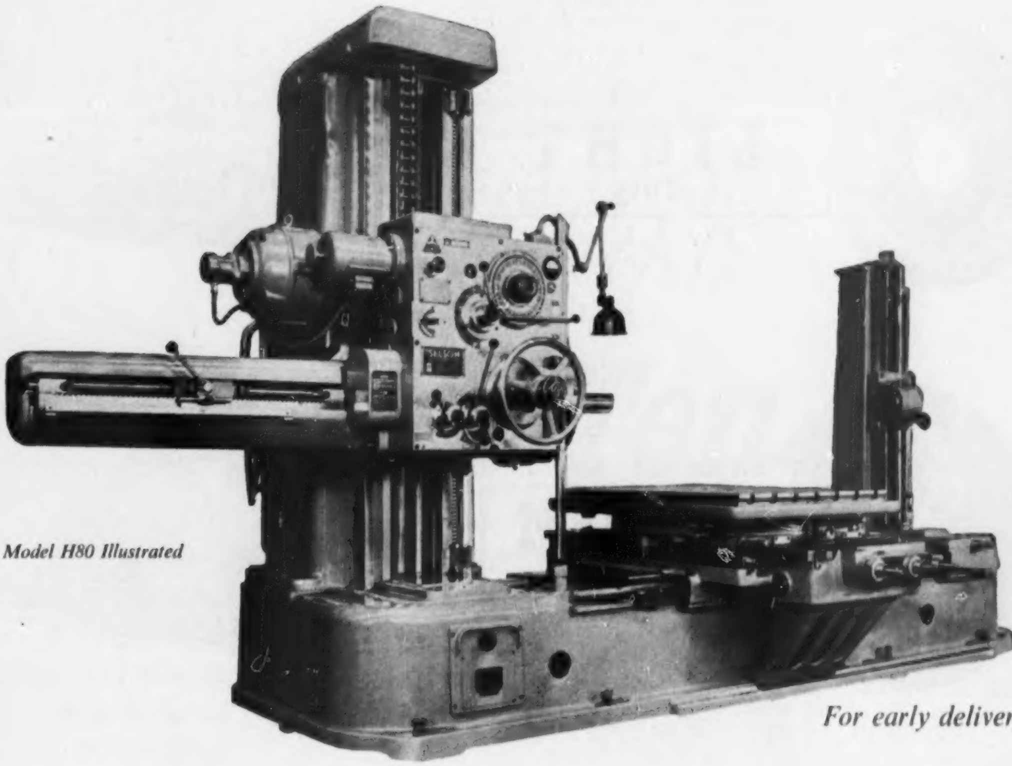

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Close limit forging of a compressor blade at the Works of Omes Limited, Barnes, S.W.13. ("The Aeroplane" copyright photograph).

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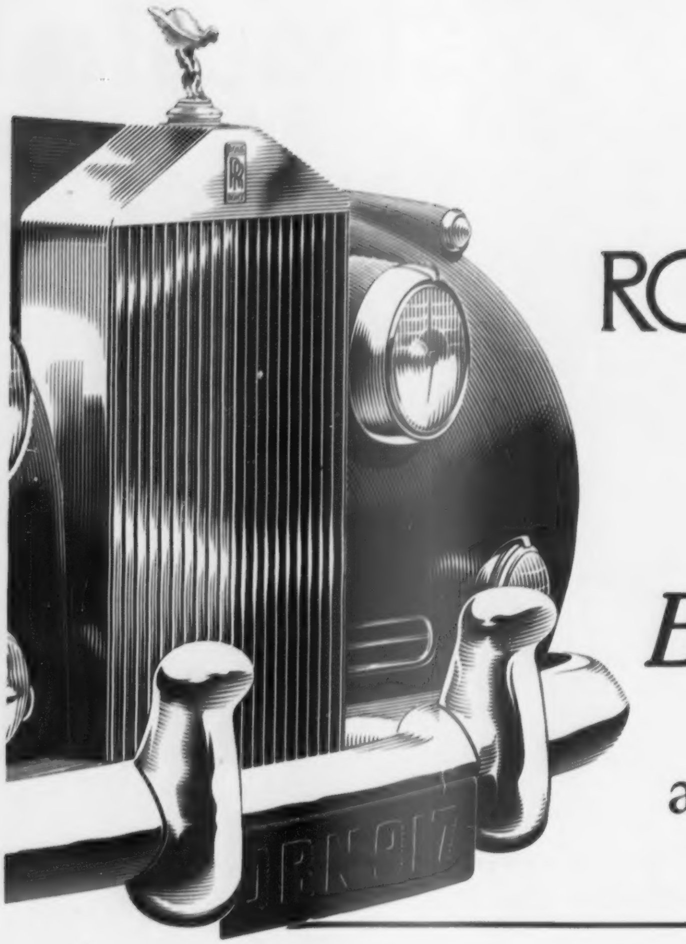

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American Trends

BIGGER, and better, if possible, but at all events bigger, seems to be the watchword of the automobile industry in the United States of America. Almost without exception, the 1956 models are bigger and more powerful than the vehicles they will replace. To the surprise of many people, the horse-power race which started some three years ago still continues. In this country and on the Continent, there are few manufacturers who produce ordinary passenger cars with engines developing more than 100 b.h.p. In America, however, a vehicle with an engine developing little more than 100 h.p. must now be looked upon as grossly under-powered.

By European standards, some of the 1956 American power units are fantastic. For normal passenger car work, it scarcely seems necessary to have an engine of 374 in^3 displacement and developing 310 h.p. Admittedly, this is big, even by American standards, but maximum b.h.p. in excess of 200 and displacements well over 200 in^3 are common. Almost universal adoption of automatic transmissions has played some considerable part in creating the demand for more powerful engines. In general, the American engines now develop maximum torque at r.p.m. appreciably higher than is customary with British or Continental engines. This may give torque characteristics more suited to automatic transmissions, but it also suggests that in the lower speed range the engines may be relatively inefficient. Even so, their reserve of power is such that at low speeds they will still develop adequate torque. Incidentally, the question of torque characteristics to suit an automatic transmission is one that should now be engaging the attention of British manufacturers.

Automatic transmissions in general have been greatly improved for 1956 cars. Not only are they said to give much smoother gear changes, but they also now make adequate provision for acceleration in the cruising range. This, of course, is a highly desirable feature. Certain makers have also greatly improved ease of servicing these somewhat complicated mechanisms.

There have been great changes in the American automobile industry since the days when Henry Ford I allowed the customer to choose the colour of the car, providing he chose black. Although such rigorous standardization could not continue, a very high level of standardization was maintained until quite recently. To-day, however, there is a tendency to offer a choice of a range of optional equipment. For example, Chevrolet offer overdrive, power steering and power brakes as optional additions to the standard model. They have also increased the number of models from 14 in 1955 to 19 in 1956.

This tendency to widen the area of customer choice is difficult to understand, since it violates the principles on which the American automobile industry has been built. In addition, it does not fit in with modern production techniques, which demand the smallest possible product variation. Probably, the reason is that the American market is now a buyer's market.

As with the British automobile industry, there is a general tendency for the basic prices of 1956 vehicles to be appreciably higher than the prices for 1955 cars. This is understandable since there is a certain degree of inflationary pressure in the United States. One price development, however, seems to be illogical. This is that optional extras, such as over-drive and power steering, are generally cheaper than hitherto. Surely, it would be much more logical to maintain basic prices and increase the price of extra equipment.

American practice still tends towards greater divergence from British and European practice as regards the size of the complete vehicle and of the power unit. This divergence will, of course, continue, but it is not likely to increase.

Wheel Balance

ALTHOUGH both tyres and wheels are manufactured to very high standards and complaints against them are rare, there is one aspect, wheel balance, which does not receive the attention it merits. In some quarters there is a tendency to take the view that users who are fussy enough to worry about such things can have their wheels balanced at a service station. This is not good enough.

Many car owners are unable to diagnose their troubles as being caused by lack of balance. Furthermore, it is fundamentally wrong to sell goods which are in any way sub-standard, and then suggest that the purchaser, or perhaps the distributor, should take the measures necessary to rectify the faults. On the contrary, each component of the wheel assembly should be accurately balanced in the final stages of manufacture and the tyre moulding process should be closely controlled to maintain concentricity within fine limits.

Cases have been reported to us where wheel and tyre assemblies of light commercial vehicles have been as much as 80 in-oz out of balance. Errors of this magnitude can

have quite serious consequences. Some of the adverse effects become apparent after only a short period of service. One of these is uneven tyre wear; another is vibration felt through the steering wheel and sometimes even through the structure of the vehicle. Another consequence may be wheel-hop and poor road-holding characteristics, which the user, not appreciating the real cause, may regard as an inherent characteristic of the vehicle.

Even more serious is the fatigue loading that out of balance forces may impose on the steering system. These forces give rise to an alternating couple about the king pin all the time the vehicle is running. The effect of this loading may be far more serious than that of the occasional severe blow experienced when the vehicle bumps into the kerb or runs over a brick in the road. It is difficult to imagine any failure more likely to cause serious loss of goodwill than a fractured component in the steering system.

Russian Production

THERE is great difficulty in finding out in what degree the Russians have developed and applied modern production techniques. The general opinion this side of the Iron Curtain is that they are behind Western Europe and this country, and even farther behind the United States of America. However, a short book that has recently come into our possession suggests this opinion may have to be revised.

According to this book, the Russians have in operation a factory for the production of automobile pistons where every operation from melting the aluminium alloy ingot to packing the finished piston for transfer to the engine builders is under completely automatic control. Unfortunately, this publication has a certain propagandist bias and internal evidence suggests that the author is not a technologist; nevertheless it contains a considerable body of interesting matter. A résumé of some of the salient features of the plant seems worthwhile.

The first piece of equipment is a pre-heating chamber for the ingots. Ingots are fed automatically into the pre-heating chamber and then into the melting furnace. A six-station turntable type of casting machine is coupled with the melting furnace. It has intermittent motion and every 15 seconds a casting station is brought under a device which automatically feeds the correct amount of molten metal to the die. Eventually the casting is removed from the die by a mechanical hand, transferred to a trimming machine for the removal of runners and risers, and thence to the annealing furnace. Because the annealing cycle takes 5½ hours, whereas the casting and trimming cycle takes only 15 seconds, the annealing furnace is of very large capacity.

An interesting feature of the annealing furnace is that an automatic hardness tester is incorporated at the exit end. This is an indent type of tester with a special electrical device for making the measurement. If a piston fails to conform to specification for hardness, the device causes a hatch to open in front of the faulty part to allow it to fall into a reject bin for subsequent return to the melting furnace.

To maintain balance between the output from the casting and annealing section and the machine line output, the former section is operated 24 hours a day and seven days a week, while the machine line is worked for two shifts on six days. A large storage hopper is interposed between the sections. It will hold more than a complete day's output from the casting machine. Contingency stocks are also held at various stages along the machine line.

Cycle times for the various machining operations are 10, 20 or 40 seconds. For the shortest cycle the pistons are handled singly, while for the others they are machined two at a time or four at a time to give completely balanced production at optimum rates. Feeding from single component machines to multi-component machines is effected automatically.

What apparently is one of the most interesting of the machines has been developed for final inspection. It takes several dimensional checks, sorts the pistons into four grades, according to skirt diameter, and marks each piston with the colour designated for its grade. With one exception, all quality control is effected by machines.

From the engineer's point of view, it is unfortunate that what little technical information is contained in this publication has to be sifted from what can only be termed propagandist verbiage. Nevertheless, what little real information there is certainly suggests that the Russians have gone a considerable way in developing and applying modern production techniques in automobile manufacture.

CONTENTS

RUBBER IN AUTOMOBILE DESIGN

Some Recent Developments by Metalastik Ltd.

RUBBER is widely used in automobile components, and new applications are constantly being developed. This trend towards its more widespread use in widely differing applications has been most marked since the war. The principal advantage of rubber is that because of its natural hysteresis, an appreciable degree of damping is obtained in applications where the material is subject to vibration. Thus, the material can be used not only as an elastic medium to isolate vibration, but also to help to damp out resonance effects. Another advantage of rubber springs is that they are not subject to corrosion as are steel ones. Rubber is also used in bearings to eliminate lubrication points and friction. In this type of application the material also helps to prevent the transmission of vibration. Bonding is necessary in many instances to use rubber to the best advantage.

Suspension springs

For many years automobile engineers have been interested in rubber as a springing medium for suspension systems, because it helps to isolate the main structure of the vehicle from noises and vibrations that develop at the point of contact between the tyre and the road, and because it enables a variable rate to be obtained without undue complication.

Metalastik Ltd., have developed so far two distinct types of spring. One has been applied mainly to independent front suspension units and the other to rear axle suspension systems. There are fundamental differences between these two types. In the case of the independent front suspension, the rubber is called upon to act only as a spring and the movement of the wheel is controlled by the geometry of the linkage. On the other hand, in the rear suspension applications, it has been thought desirable for the rubber to locate the axle longitudinally and transversely and also against torque reaction, since this could conveniently be managed with the layout adopted.

Rubber is used most effectively when loaded in shear: that is, in this condition the greatest possible amount of strain energy per unit weight is absorbed. However, it has been found desirable to superimpose compression loading on the shear, so that under alternating load conditions the stress in the material does not pass repeatedly through the zero value. This measure increases the fatigue life and reduces the risk of oxidation of the rubber. Moreover, if the material were to be loaded in tension, it would be more liable to damage by sharp stones flung up from the wheels, and such damage would tend to spread more readily.

Although the hysteresis of the rubber reduces the load on the shock absorbers,

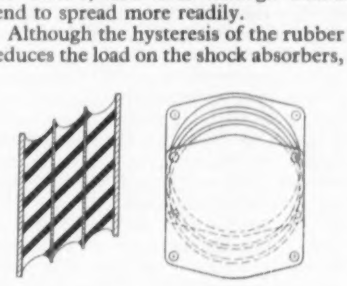


Fig. 2. Detail of the rubber spring for the independent front suspension of the B.M.M.O. bus

it is not enough to make the incorporation of a shock absorber unnecessary. Hysteresis characteristics can be varied by altering the mix, but generally very high rates of inherent damping can only be obtained at the expense of stress range or creep characteristics. Nevertheless, the search for an improved grade of rubber with very high damping characteristics continues. At present a natural rubber mix that gives high resilience and low creep is generally chosen for suspension applications. If high damping is obtained it is desirable to increase the thermal conductivity of the mix too, so as to avoid the attainment of dangerously high temperatures in the interior of the rubber.

Independent front suspension

A particularly successful independent front suspension design in which rubber is used as the springing medium, is that employed on the Birmingham and Midland Motor Omnibus Company's bus that was described in the December, 1953, issue of *Automobile Engineer*. From Fig. 1 it can be seen that the cylindrical rubber springs comprise alternate layers of rubber and metal plates; the intermediate metal plates are incorporated to resist the bulging of the rubber, and thus, to increase the load-carrying capacity of the unit.

Fig. 2 shows that the rubber is moulded initially to a special shape, so that in the normal working condition stress concentrations at the edges are reduced to a minimum. The relationship between the length of spring,

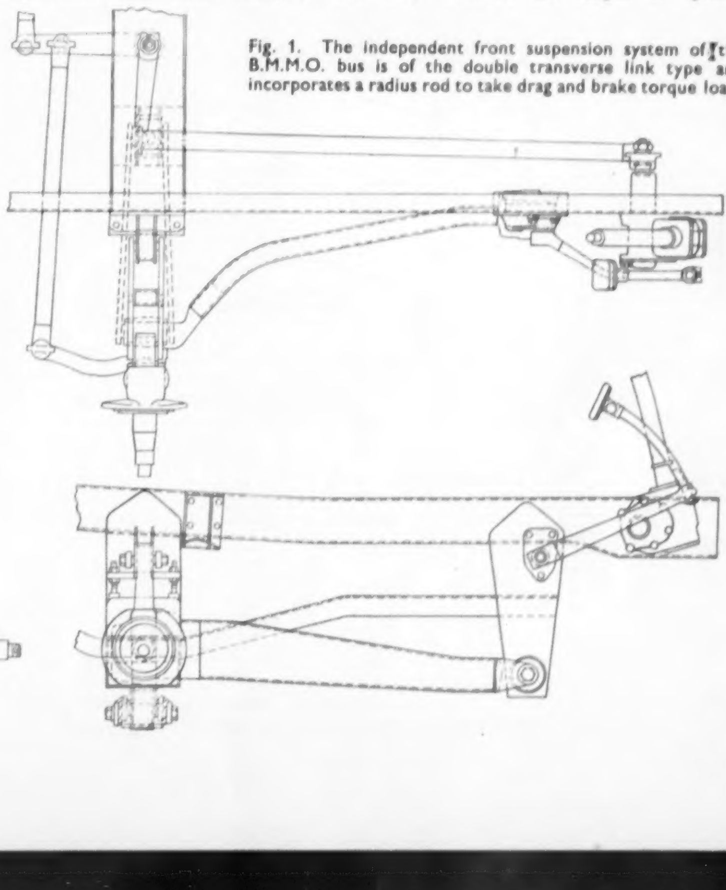


Fig. 1. The independent front suspension system of the B.M.M.O. bus is of the double transverse link type and incorporates a radius rod to take drag and brake torque loads

diameter and thickness of rubber has to be maintained within certain specified limits to obtain sufficient deflection to give the required ride characteristics, without the spring buckling or being overstressed. Therefore, in this application the spring has been divided into two stages, separated by an intermediate steady plate anchored to the centre of the upper transverse link. As this plate is maintained substantially parallel to the end faces of the spring, bending and buckling tendencies are eliminated, while at the same time, the proper shear and compression deflections can be freely obtained.

The design is influenced not only by the sprung weight on the front axle, but also by the periodicity most suited to the operating conditions. Other controlling factors are, the space available and the regulations of the Licensing Authority. In British public service vehicles one of the limitations is the need to maintain a minimum ground clearance of 10½ in under the forward part of the vehicle. In countries where a smaller ground clearance is permitted, the lower link can be nearer to the ground, so that more room is then available for the spring.

An alternative suspension arrangement is shown in Fig. 3. This is a Metalastik design similar to that of the B.M.M.O. bus. It is built to the maximum British legal dimensions, but the periodicity is also low enough to suit export markets. Therefore, the springs are larger and are fitted under the chassis frame. To maintain the ground clearance, it was necessary to make two modifications. The inner pivots of the transverse links were moved up slightly, relative to the outer ones. This has given a slight increase in camber change on rebound, but not enough to affect adversely the performance of the suspension unit. The second modification was the substitution of a hemispherical bonded bearing for the Spherilastik bearing at the inner end of the lower link. That an appreciable saving in space has been attained by the employment of these bearings can be seen by comparing Figs 3 and 4.

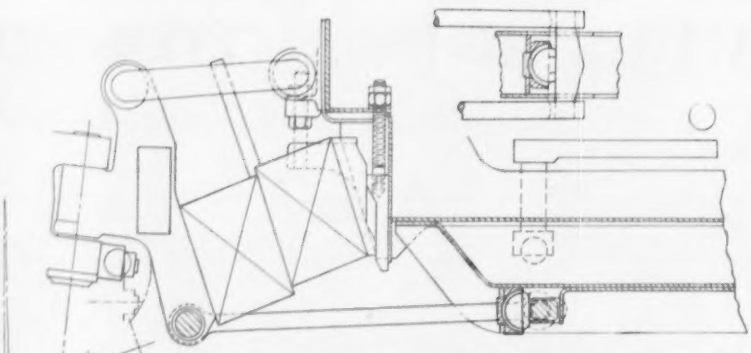


Fig. 3. Arrangement of a low periodicity suspension system suitable for export markets

The reason why a hemispherical bearing can be employed in this application is that the lower link is invariably in tension because of the compression load in the spring. Nevertheless, a stop has been incorporated to prevent the bearing from jumping out of its seating in case the tyre should be subjected to an exceptionally severe lateral impact. In this system, height adjustment is effected by a double wedge interposed between the spring and the cross member. The compression of the spring is effected by means of this wedge after the assembly of the suspension unit. A screw jack is employed to adjust the position of the double wedge; the nut that operates it is trapped in such a manner that it can be used to effect positive movement in both directions.

Another design that has been developed is shown in Fig. 4. This design is similar to that already described, but is for greater wheel-loading. As the ground clearance requirements are not so critical, the Spherilastik type of bearing is used for the pivoted lower transverse link, as well as for that of the upper link. In Fig. 4 the load diagrams for the fully laden position only are given; the diagrams for the full range of movement of the suspension are given in Fig. 5. The minimum load in the lower transverse link at —3 in deflection is 6,900 lb. This is appreciably more than the force that is necessary to cause the tyre to skid over the road surface. Therefore the lower link is invariably in tension and can be designed without regard for bending or buckling.

Under normal conditions the loads in the lower links on each side of the vehicle are in balance, so their pivots are carried by a common bracket on a light bridge-piece attached to the frame cross member. The neutral axis of the main cross member is more or less in line with the resultant thrust applied through the inner face of the spring. In this position the cross member also forms a convenient anchorage for the pivot of the swinging arm of the divided track rod steering system. Although the position of the pivots of the lever in the divided track

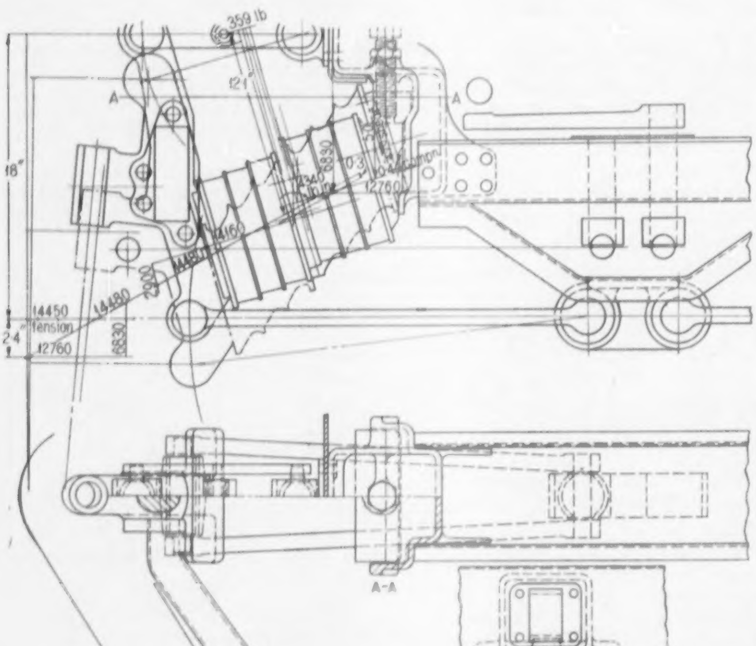


Fig. 4. A suspension layout for applications where the wheel loading is relatively heavy. The loads and dimensions are for the fully laden condition

rod steering system, in this example, is not absolutely theoretically correct, in practice the inconsistency is not great enough to have any noticeable effect. The loads in the top link are relatively small, since they are mainly due to cornering rather than vertical loading and shocks.

As can be seen from Fig. 6, the load deflection characteristic is a compromise between constant rate and constant periodicity. A closer approach to constant periodicity could be obtained by the employment of a larger spring and shorter transverse links. However, it is usually considered important that the relative lengths of the links are such as to eliminate tyre scrub, while at the same time their absolute lengths must be such as to obtain the required degree of non-linearity.

Since in this system, the transverse links are employed in conjunction with a torque reaction arm, the cross member does not have to react brake torque. Therefore, from this point of view it can be of channel or I-section. However, in many designs, notably of private cars, the box-section front cross member helps to give torsional stiffness to the frame. This same type of direct loaded spring has also been applied to single and double axle bogie schemes, in conjunction, of course, with locating linkages of various kinds.

Toggle-link, rear axle springs

A toggle-link type of rear suspension is used on the B.M.M.O. bus, Fig. 7. Each link is a rigid assembly that connects the angle bracket on the axle to a forked fitting on the body structure. The turn-buckle fitted diagonally between the upper and lower components, or *stretchers*, of each link, is incorporated only for setting the height of the suspension and to compensate for the initial creep. After the height has been stabilized, further adjustment is not normally required. In the tare-load position the links are all horizontal and the whole weight is resisted by torsion in the bushes. Deflection in either direction from this position pulls the pins into an eccentric position in the rubber bushes and so gives the progressive increase in rate shown in Fig. 8.

The angular setting of the links, as viewed from above, has two main purposes. One is to increase the resistance to roll, which it does by widening the effective spring base. The second object is to provide resistance to transverse movement of the axle relative to the sprung mass. The bushes act as pin joints at the ends of the links, which, therefore, are loaded in direct tension or compression, and the bending stresses on them are negligible. Originally, additional links were connected to the axle to react the driving and brake torque, but they were found to be unnecessary since the reaction could be taken in the same way as with a laminated spring, that is, entirely by the Metalastik toggle links. The design of the chassis or body details concerned with the attachment of the springs is, of course, most important, particularly with regard to the reaction of the horizontal components of the forces due to the eccentric movement of the pins in the bushes as the suspension deflects from the normal static position.

For another suspension system, Fig. 11, which is designed for loads that are 50 per cent greater than those experienced in the B.M.M.O. bus, the length of each link has been increased from 14 in to 15·4 in. In this way, a slightly lower periodicity and a greater range of

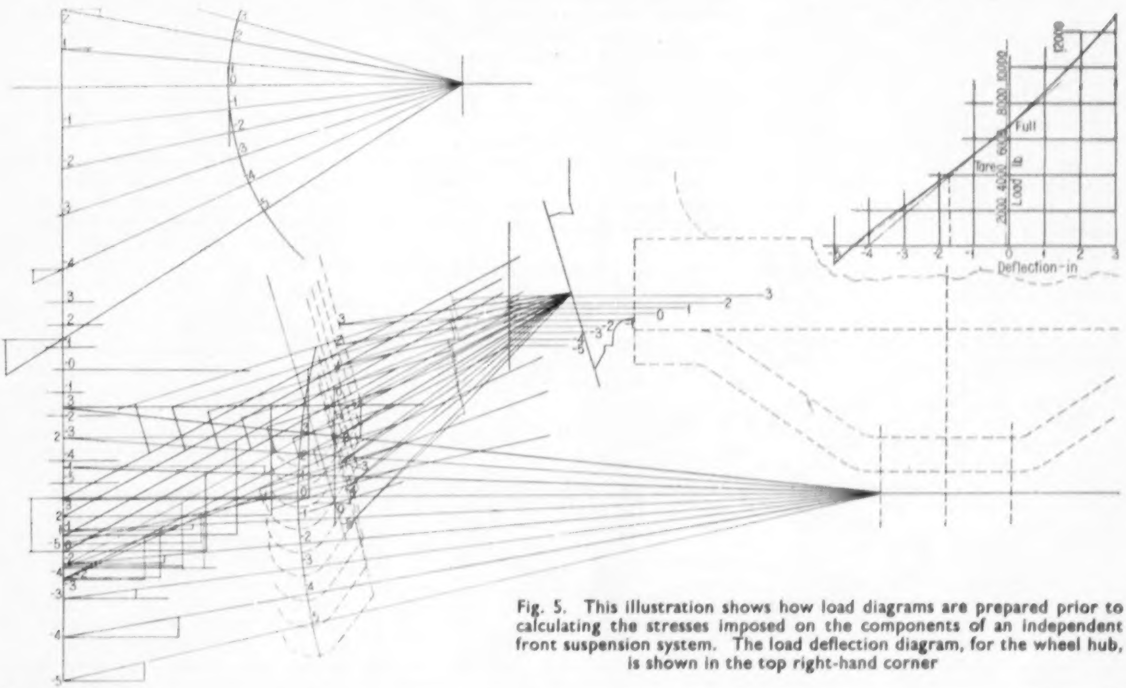


Fig. 5. This illustration shows how load diagrams are prepared prior to calculating the stresses imposed on the components of an independent front suspension system. The load deflection diagram, for the wheel hub, is shown in the top right-hand corner

Wheel Travel	Shear		Compression		Res.	Vert. Components				Centre B.M.
	Defl.	Load	Defl.	Load		Top	Bottom	Spr.	Total	
3	7·45	4510	2·48	24370	24820	−1350	−2900	11400	12950	36000
2	6·61	4000	2·11	20720	21080	640	1550	9800	10710	23600
1	5·74	3475	1·76	17300	17620	240	640	8350	8750	13700
0	4·79	2900	1·44	14160	14480	—	—	6830	6830	4340
−1	3·81	2305	1·20	11790	12000	90	−460	5600	5230	−1800
−2	2·78	1680	0·97	9530	9680	70	−740	4380	3710	−7250
−3	1·68	1016	0·80	7860	7900	−120	−830	3230	2280	−12250
−4	0·48	291	0·68	6680	6680	−530	−870	2230	830	−18000
−5	−0·87	−526	0·64	6280	6300	−1510	−820	1320	−1010	−26400

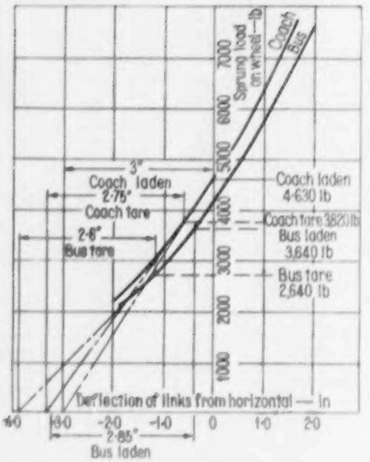


Fig. 6. Load deflection curves for the independent front suspension of the B.M.M.O. vehicles

deflection have been obtained. Larger bushes are employed and the turnbuckles are of greater capacity. The axle loading for which this suspension is designed, is 4,350 lb/side, tare, and 8,530 lb/side, fully laden.

Under most conditions, the turnbuckle is heavily loaded in tension and the stretchers are relatively lightly loaded. This follows from the torsional nature of the loading of the bushes. It can be seen, therefore, that the four bolts that connect the angle-bracket to the axle are not equally loaded. Nearly all the tension is taken by the top inner bolt, which is carried right through to the other side of the axle. Provided that the diameter of this bolt is reduced between its threaded ends to slightly less than the root diameter of the threads, the angle-bracket casting could probably be made of aluminium alloy, but the end piece should be of steel or malleable iron.

In the design illustrated in Fig. 11, the two top bolts are identical, and the two bottom ones, which are lightly loaded in tension, are fitted through flanges. This arrangement has been adopted for the sake of simplicity. So far as is practicable in the space available, the fork that carries the rubber bush at the chassis end of each unit is inclined in the direction of the resultant of the applied load. This bush is keyed to a flanged sleeve that is secured by six bolts to each arm of the fork. By the employment of this large number of bolts, adequate bearing area has been obtained to prevent the bolts from crushing the relatively thin-gauge plate from which the fork is constructed.

In most passenger-carrying vehicles the variation of weight on the rear axle is far greater than on that at the front. Therefore, the provision of a suspension of constant periodicity is both more important and more difficult at the rear. The toggle link type of suspension unit enables constant periodicity to be obtained without any increase in weight. The progressive stiffening of the spring, as the deflection in either direction from the static position is increased, helps to reduce the angle of roll. This feature is particularly important in connection with double-deck buses, which, in this country, have to pass the 28 deg tilt test. The relatively wide spring base of the independent front suspension is also an advantage in this connection.

The main advantages claimed for the

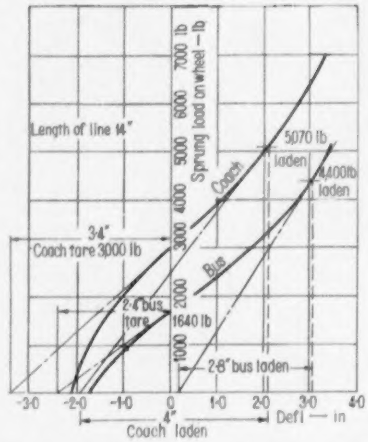


Fig. 8. Load deflection curves for the toggle link rear suspension of the B.M.M.O. vehicles

Metalastik front and rear suspension systems are as follows. All bearings and other moving parts subject to wear are eliminated, so that no maintenance is required for long periods. The ride is improved because of the absence of friction such as is experienced with leaf spring type suspension units; moreover, the spring characteristic remains constant, whereas with laminated springs it does not, because of wear and friction between the leaves. Rubber suspension is lighter than more conventional arrangements and the unsprung weight also is reduced. Another important feature of the system is the good roll resistance obtained. Hitherto, objections have been raised to rubber suspension springs on the grounds that their performance over extended periods of service is unknown. However, some experience in this respect has now been gained and the indications are that rubber springs do not deteriorate in the course of long periods of service. For example, bolster springs similar to the B.M.M.O. front suspension springs have now been in service for eight years on London Underground bogies.

Bushes in suspension systems

Rubber can be used, of course, for other components in suspension systems. There are many different types of bush available, each designed for a specific duty. Most of the types commonly in use on private cars are well known. Although the Ultra Duty bushes are popular, the most widely employed bushes in suspension systems of current design are the B.C. and B.C.T. types. In these the rubbers are of conical section and are flanged so that they can react positively to axial as well as radial loading.

The rubber bushes used in suspensions have, of course, a torsional rate, and so contribute to the spring rate at the wheel. However, in most instances, the range of movement is such that they cannot be allowed to carry load, but must be clamped up in the mean position. Too high a rubber rate in a

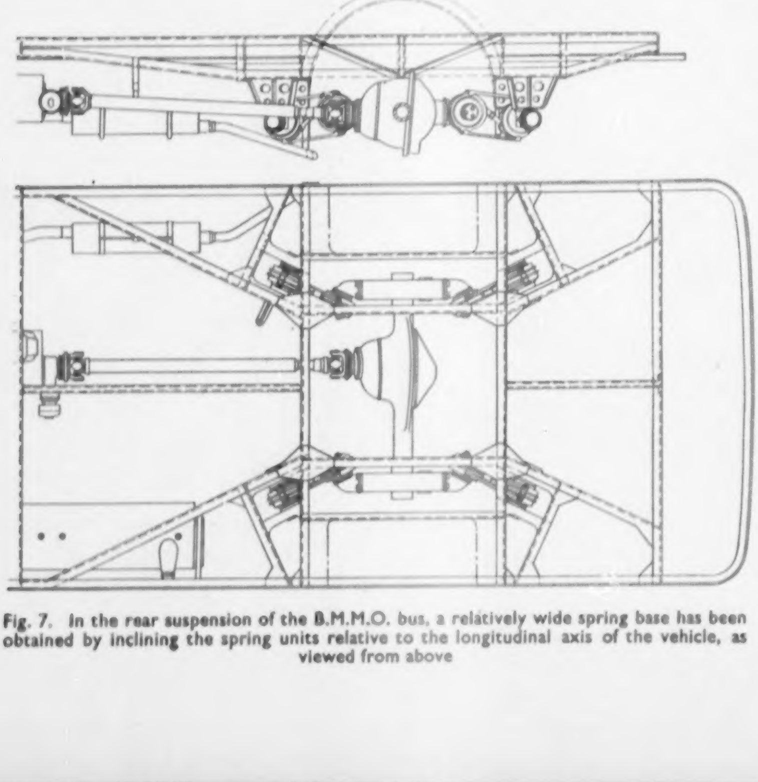


Fig. 7. In the rear suspension of the B.M.M.O. bus, a relatively wide spring base has been obtained by inclining the spring units relative to the longitudinal axis of the vehicle, as viewed from above

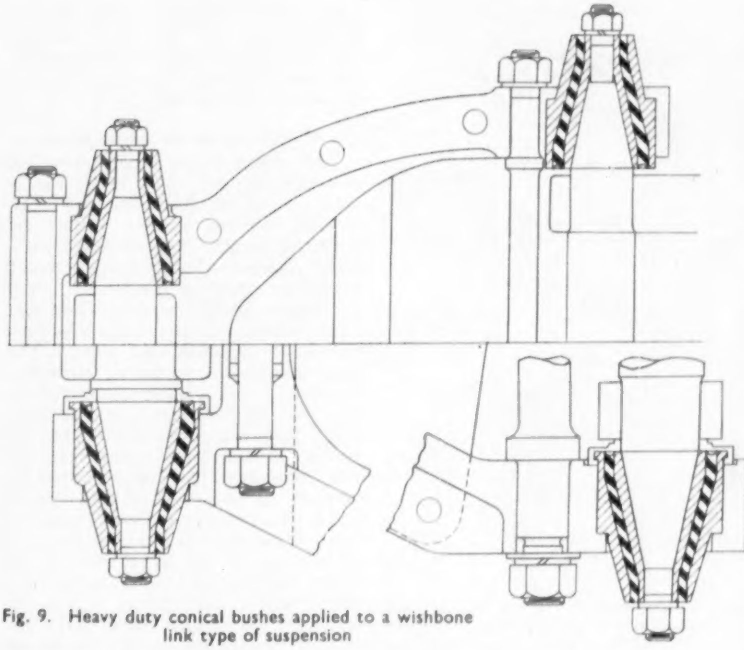


Fig. 9. Heavy duty conical bushes applied to a wishbone link type of suspension

suspension means that the steel spring must have a lower rate, but since it still has to carry the same normal load, it is more highly stressed. Rubber bushes in independent front suspension systems have sometimes been blamed for brake judder. However, in some experiments judder has been found to occur both with rubber and with metal bushes.

A recent development is the introduction of bushes for independent suspension systems on commercial vehicles. This type of suspension is attracting increasing interest among commercial vehicle operators and manufacturers. The main difference between commercial vehicle and private car applications is in the magnitude of the loads that have to be carried.

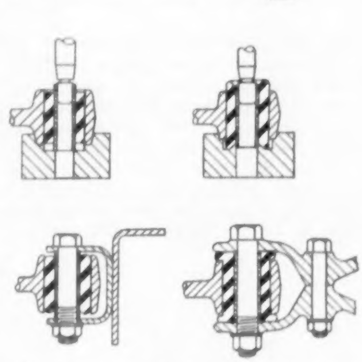


Fig. 10. Rubber bushes with only inner metal sleeves

A transverse wishbone link type of suspension in which these heavy duty conical bushes for commercial vehicles are incorporated is shown in Fig. 9. The important differences between these bushes and the bonded cone types are: the section of their rubbers is of uniform thickness throughout the length of the bush, they are mounted on a tapered spindle, and the rubber is bonded to both inner and outer metal sleeves. In the bonded cone bushes, the inner peripheries of the rubber bushes are parallel, their outer peripheries are of conical form, and they are carried on plain cylindrical spindles.

To reduce the concentration of stress between the end faces of the rubber bushes and the metal to which they are bonded, the ends of the heavy duty bushes are parallel for a short length. These end faces are also profiled in such a way as to reduce stress concentrations. As can be seen from the illustration, axial pre-load is applied to the bushes by means of the bolts that clamp together the two arms of each wishbone link. This places the bushes initially in compression to increase their fatigue life.

For many years it has been the practice of Metalastik Ltd. to apply pre-compression to the rubber in their Ultra Duty bushes. In most instances this is done by expanding the inner sleeve after the bonding operation. This precompression has led to increased fatigue life and greater load carrying capacity. In the Metalastik I.S., *inner sleeve*, bush this same principle is applied, but the bush has not an outer sleeve and it is fitted directly in the housing. It is therefore unnecessary to machine the bore of the housing. Precompression is applied to the rubber by expanding the inner sleeve with a taper-ended drift. As can be seen from Fig. 10, these bushes can

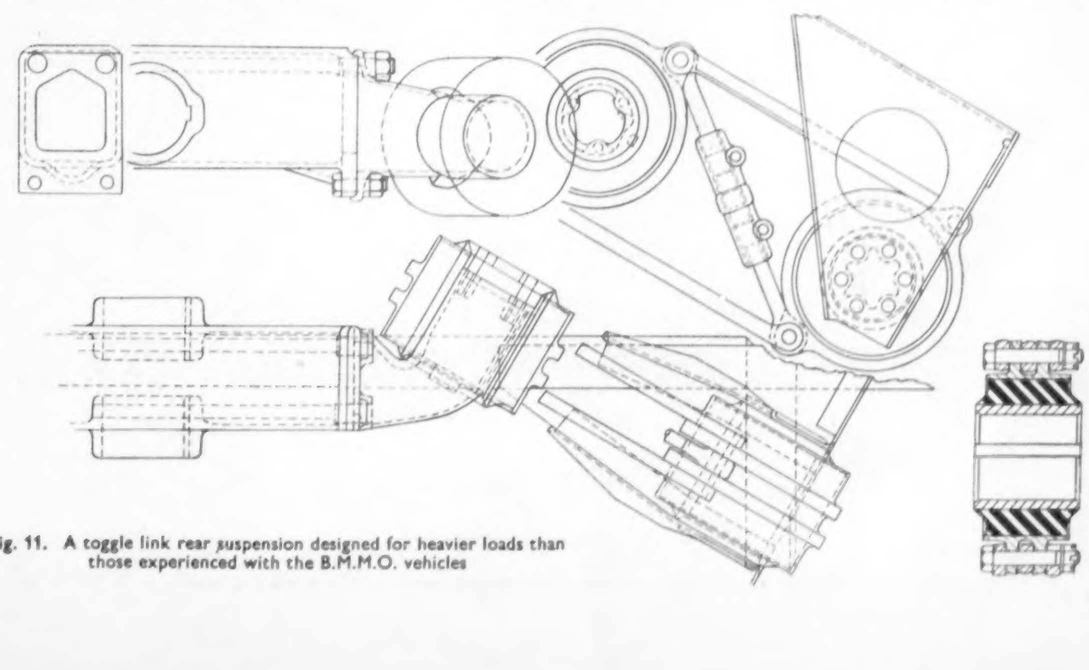


Fig. 11. A toggle link rear suspension designed for heavier loads than those experienced with the B.M.M.O. vehicles

be designed in such a way that flanges are turned up on their ends when they are clamped between the arms of the fork that carries the eye. The upper two diagrams in Fig. 10 show how the metal sleeves are expanded to compress the rubber.

Bushes containing relatively thick sections of rubber will tolerate a certain amount of misalignment or universal action. However, if relatively large angles of rotation about the centre of the bush, as distinct from about the axis of the bush, have to be accommodated, or if the rubber has to be of thin section to give more positive radial location, spherical types of bearing must be employed. Some arrangements incorporating spherical bearings and other types of bush are shown in Fig. 13. In the spherical joints, the rubber is bonded to the metal ball and pre-compression is applied by the clamp action between the halves of the pressed steel spherical housing.

Where the loading is particularly heavy, a more robust type of bearing is needed. Spherilastik bearings have been designed for this type of application They incorporate a spherical inner component that can be either hollow in the form of a bush, or solid in the form of a pin, Fig. 12. The rubber is of relatively thin section and the housing is in three sectors, so that when the unit is assembled into the eye of the component to which it is to be fitted, the three sectors are forced radially inwards to apply pre-compression to the rubber. An incidental advantage of the spherical type of bearing is that

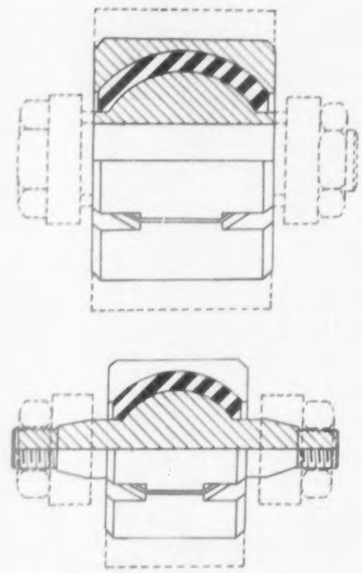


Fig. 12. Spherilastik bearings are designed for applications where the loads are severe and universal action is required

since the diameter of the ends of the rubber portion of the bush is relatively small, the escape area is also small. This, of course, is an important factor in the design of rubber bushes because, under heavy loading, they tend to be squeezed out from between the inner and outer components, so the smaller the escape area, the greater the load capacity of the bearing. The advantages claimed for Spherilastik bearings in particular are the large angular movement in all planes and heavy radial and axial load capacities in relation to the size of the bearing.

Other suspension applications

The rocker beam arrangement for twin-axle layouts has been widely used. Even on goods-carrying commercial vehicles, rubber bushes are attractive because they eliminate lubrication points and reduce fatigue loading of the structure or mechanism. For passenger-carrying vehicles they also have the additional advantage of helping to reduce vibration and noise. The pivot bearing is the most interesting feature of the system illustrated in Fig. 14. Its pivot pin is carried in an Ultra Duty bush in the eye of a bracket bolted to the chassis frame, and the two components of the rocker beam are pivoted on each side of the eye on rubber bushes round the ends of the pin. With this arrangement, the angle of rotation of the pin relative to the outer sleeve of each bush is half that which would be obtained if the pin were, for example, clamped in the eye of the bracket bolted to the frame. Thus, the diameter of the bush assembly is relatively small for a given load-carrying capacity.

In a description of the London Transport "Routemaster" bus published in the January and February, 1955, issues of *Automobile Engineer*, mention was made of the fact that rubber sandwich type units are interposed between the rear axle and the trailing link arrangement of the suspension

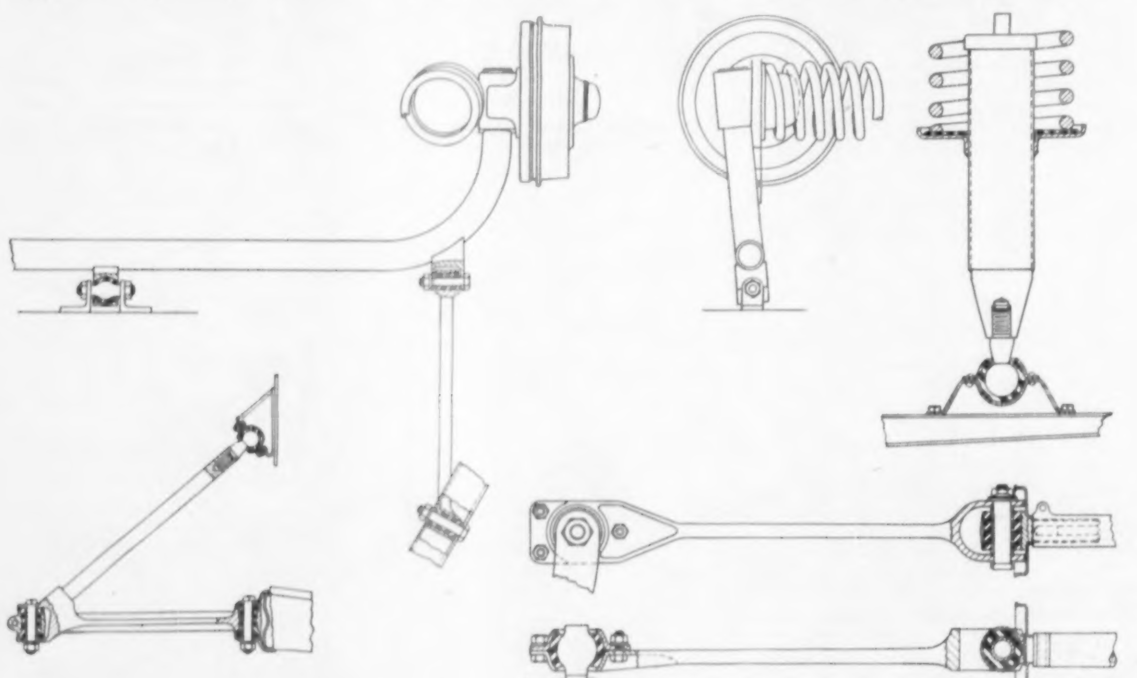
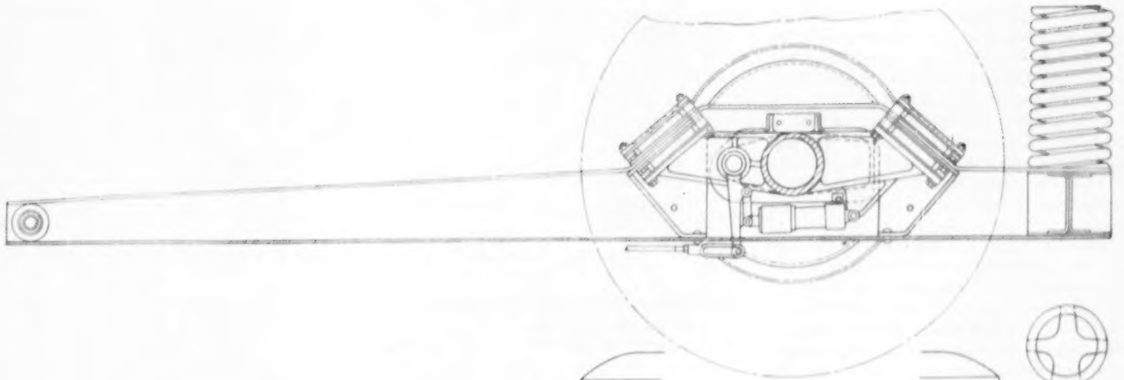


Fig. 13. Examples of applications of rubber bearings to suspension and steering systems



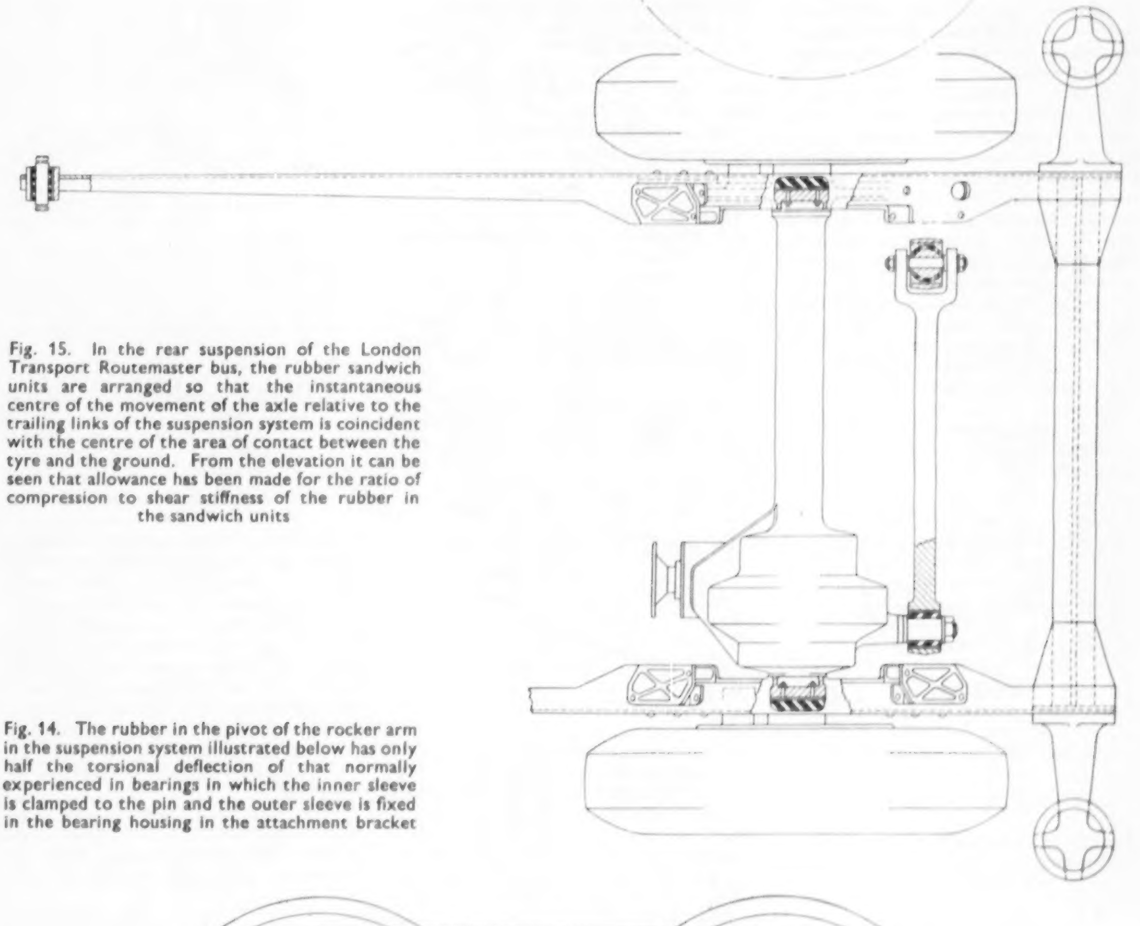
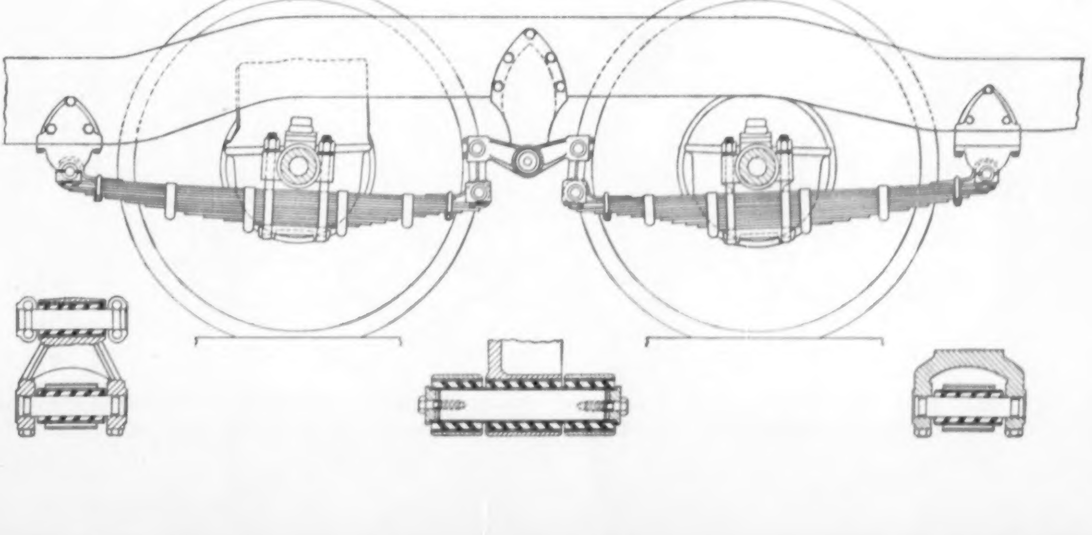


Fig. 15. In the rear suspension of the London Transport Routemaster bus, the rubber sandwich units are arranged so that the instantaneous centre of the movement of the axle relative to the trailing links of the suspension system is coincident with the centre of the area of contact between the tyre and the ground. From the elevation it can be seen that allowance has been made for the ratio of compression to shear stiffness of the rubber in the sandwich units

Fig. 14. The rubber in the pivot of the rocker arm in the suspension system illustrated below has only half the torsional deflection of that normally experienced in bearings in which the inner sleeve is clamped to the pin and the outer sleeve is fixed in the bearing housing in the attachment bracket



system. This layout was adopted to allow the trailing arm on one side to move relative to that on the other side, to allow one wheel to ride over a bump more or less independently of the other, and also to reduce the transmission of vibration and noise to the structure. This relative movement is also necessary to prevent the axle acting as an excessively stiff anti-roll rod.

Details of the arrangement of the rubber components are given in Fig. 15. The layout of the sandwich units is of the vee-type and the angle of the vee is such that the rubber units are focused on the point of contact between the tyre and the road; in other words, this contact point is the centre about which the axle moves relative to the rubbers. From the illustration it can be seen that lines drawn through the centres of these units normal to their end plates do not intersect at ground level. However, this does not mean that the units are shown as being set incorrectly, for allowance has, of course, been made for the ratio of compression to shear stiffness of the rubber components. The way in which this allowance is made is described in an article entitled "Engine Mounting", in the March, 1953, issue of *Automobile Engineer*.

The relative movement between the axle and the trailing arms is provided for by the shear deflection of the rubber mountings. Horizontal reactions due to the braking and driving loads, which act at the centre of the area of the contact between the tyre and the road, are taken by the mountings in compression. Reaction to the brake and drive torque is therefore adequate, while the anti-roll characteristics are controlled. Lateral location of the axle relative to the trailing links is effected by rubber buffers interposed between a bracket at each end of the axle and each trailing link. The whole of the assembly, comprising the axle and its trailing links, is located by a Panhard rod. This rod is secured to the axle by means of an Ultra Duty bush and to the vehicle structure by a Spherilastik bearing.

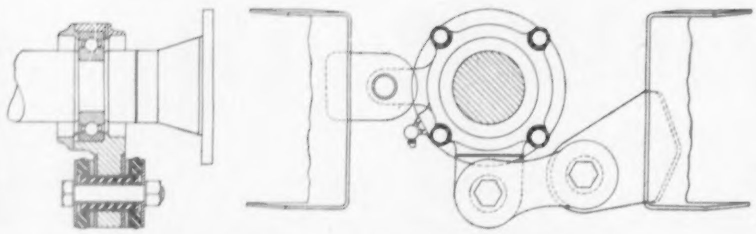


Fig. 16. Mounting for a propeller shaft intermediate bearing

Rubber in transmission systems

Intermediate bearings, about midway between the ends of propeller shafts, are incorporated to increase whirling speeds and to reduce the size of or to eliminate altogether the tunnel in the body floor. Unfortunately, if the shafts connected by a Hooke's joint are not in line, they are subjected to a cyclic bending couple, twice per revolution. Conventional flexible mountings for the centre bearings generally resonate with the lateral disturbing forces at a certain speed in the running range. Accordingly, Rolls Royce Ltd. have developed a special mounting, which is extremely flexible laterally so that resonance occurs at a very low speed. The system is based on links fitted with flexible rubber bushes. Friction damping is effected by discs spring loaded by rubber washers in compression.

Metalastik Ltd., have a licence from Rolls-Royce Ltd., for the manufacture of this type of mounting. Fig. 16 shows the application to another car.

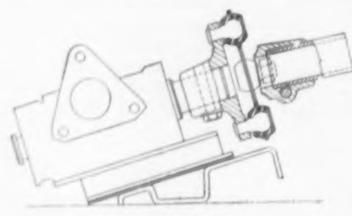


Fig. 20 Steering column coupling

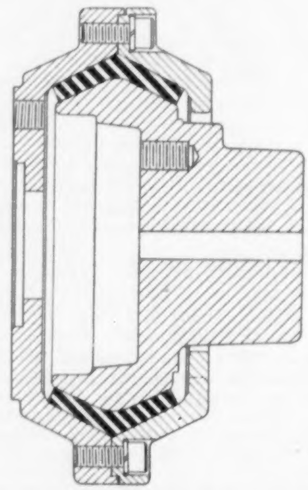


Fig. 21. A marine transmission coupling

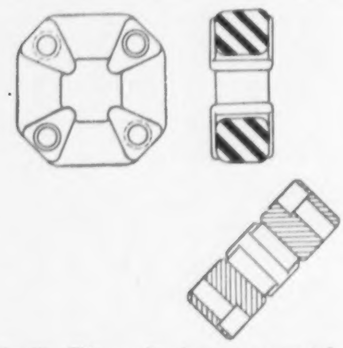


Fig. 17. This coupling is more compact, but cannot be so heavily loaded as the Rotoflex unit, which has six bolts

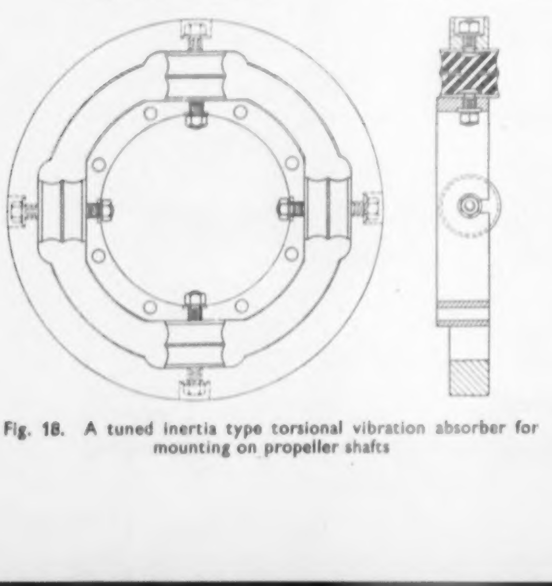


Fig. 18. A tuned inertia type torsional vibration absorber for mounting on propeller shafts

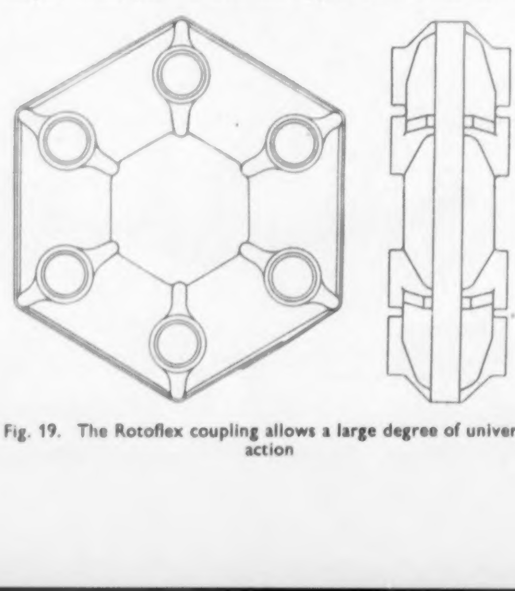


Fig. 19. The Rotoflex coupling allows a large degree of universal action

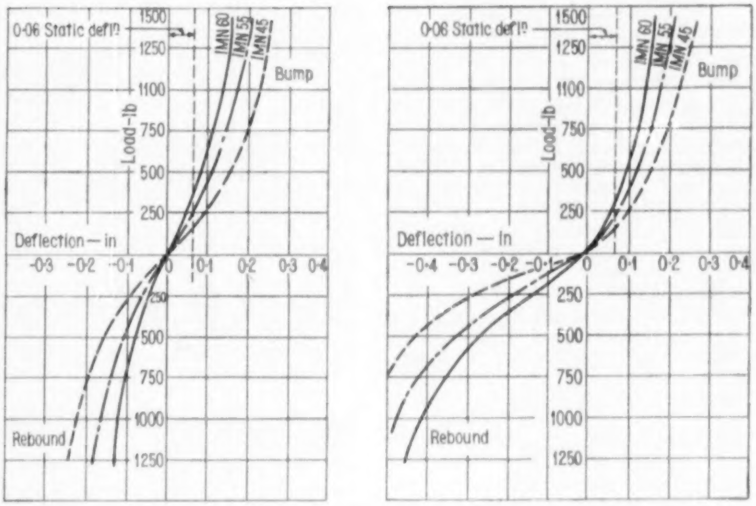


Fig. 22. Load deflection curves for two Metalastik C.R. type mountings

A lug extending downwards from the bearing housing is pivoted in a torsionally flexible rubber bush at one end of a link, which has its other end similarly pivoted on the frame. If the propeller shaft bearing moves horizontally, it pivots about the rubber bush in its downward-extending lug, and the sideways rate and periodicity are low. Excessive sideways movement and vertical movement, are restricted by a peg on a lug projecting sideways from the bearing housing. This peg projects into a hole in a lug mounted on the frame, and there is a clearance between it and the sides of the hole.

When the vehicle starts from rest it runs through resonance, but the friction damper prevents amplitude build-up. The outer plates of the link exert pressure through rubber rings on to inner plates. These inner plates each bear on a ring of friction material, which they force against the lug of the bearing housing at one end of the link, and against the frame attachment lug at the other end. Thus, the friction surfaces slide relative to one another as soon as the housing moves, so the effectiveness of the damping is as great as possible.

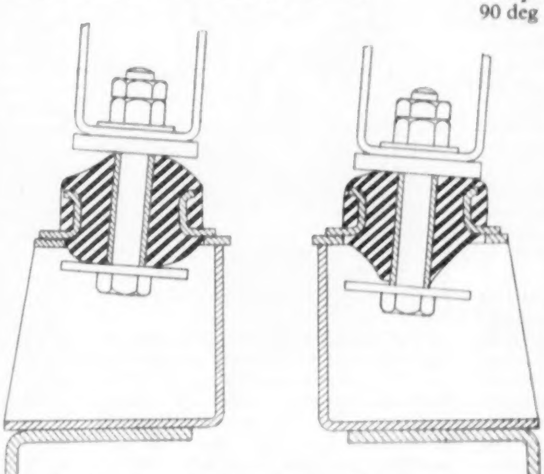


Fig. 23. Two C.R. type cab mountings, one in the bump and the other in the rebound position

On some vehicles, gear noise or rattle is experienced, as a result of torsional vibrations of the transmission system at low or moderate speeds in top gear. One way of overcoming this difficulty is to incorporate a tuned inertia-type torsional vibration absorber. A unit of this type is illustrated in Fig. 18. It is bolted to the flange of the universal joint on the propeller shaft and comprises an inertia ring separated from the flange by four rubber bobbins interposed radially at intervals of 90 deg between the ring and the flange. These bobbins are of the double-sandwich type. The intermediate, metal plate in each is used to prevent the bobbin from bowing or the rubber from bulging excessively under the pre-compression load and when the unit is deflected in shear.

Another method of overcoming the difficulty is to employ flexible couplings at the ends of the transmission shaft. This lowers the natural frequency to a point outside the normal running range. A coupling of this type, namely, the Rotoflex unit, is illustrated in Fig. 19. It comprises a hexagonal ring of rubber in which are bonded six eyes for the bolts which connect it to the two com-

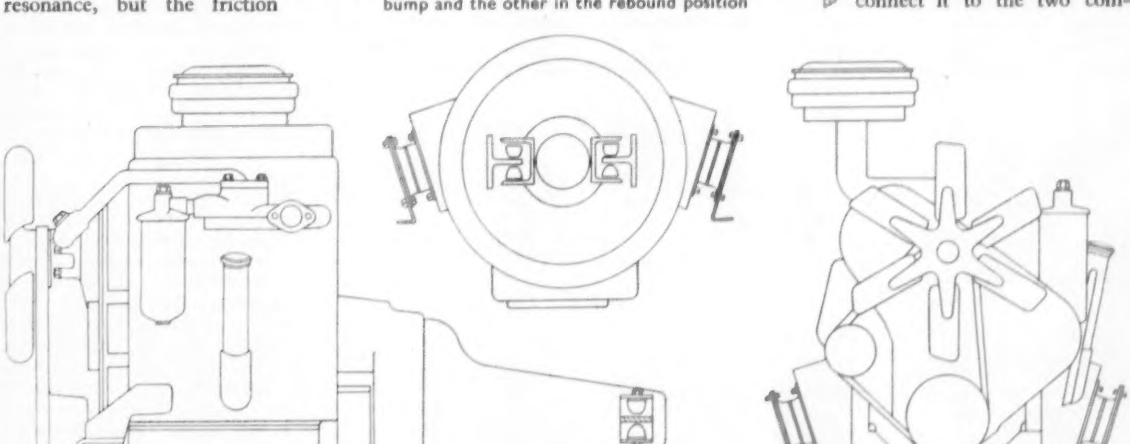


Fig. 24. The Perkins P3 engine mounting arrangement, showing how rubber snubbers are applied at the tail end of the gearbox extension

panion flanges. This ring is placed in pre-compression, for assembly purposes, by a hexagonal steel band round its periphery. The band is removed after assembly. Another coupling, but one that is designed for lighter loads, is illustrated in Fig. 17. This coupling has four holes instead of six for attachment to the companion flanges.

A flexible coupling for application to steering columns is illustrated in Fig. 20. It is fitted between the lower end of the coupling and the steering box. The object of incorporating the coupling at this point is to allow for misalignment between the column and the box, and also to help to prevent the transmission of vibration up the column. The coupling comprises two pressed steel plates, in each of which are formed four half-housings for the rubber bushed ball joints that are connected to the companion flanges. The two plates are riveted together so that the half-housings totally enclose the ball joints and apply pre-compression to the rubber. The rubber is bonded to the balls. Thus the bond is effected at the face that is nearest to the centre of the ball, that is, the bond adds to the strength of the unit in its most highly stressed area. There are, of course, many other applications for this type of bearing.

Another transmission coupling is illustrated in Fig. 21. So far, this has been used only in marine applications but there probably are others in which it could be employed to advantage. It is a simple conical coupling designed to allow for a certain amount of misalignment, as well as to take torque and axial thrust. The double-conical centre portion is on the end of the transmission shaft and the two-piece housing is bolted to the output shaft from the gearbox. The bolts that clamp the two pieces of the housing together apply pre-compression to the rubber ring, which is interposed between the housing and the centre piece, to which it is bonded. Positive stops are incorporated to limit relative motion.

Cab and engine mountings

It is perhaps surprising that cab mountings, in spite of their relatively small deflections, of the order of only ¼ in or less, can noticeably affect the ride on very rough tracks, such as the pavé at the M.I.R.A. testing ground. Recently, in the course of some intensive and extensive, tests mostly on pavé surface at M.I.R.A., it has been found that the cab ride is most affected by the bump movement of the mountings, which should, therefore, be kept as small as reasonably possible. On the other hand, the stressing of the cab structure, the relief of which is the major object of flexible cab mountings, is affected mostly by the rebound movement, which should therefore be left as free as possible initially and progressively limited, except at one or two mounting points, where it must be more closely restricted to anchor the cab. This experience has led to the production of the C.R., *controlled*

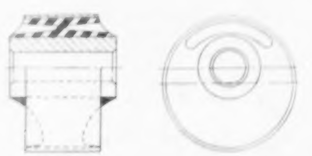


Fig. 26. The Metaxentric bush

rebound, cab mountings illustrated in Fig. 23. The load deflection curves for this type of mounting are shown in Fig. 22.

The development work showed that each cab and chassis frame combination has to be treated as a separate problem. This is because frame deflections relative to the cab vary considerably as between one type of vehicle and another. For example, in some designs the cab is almost entirely forward of the centres of the front wheels, whereas in others the wheels are well forward of the cab. The type of body fitted also influences frame deflections: tanker

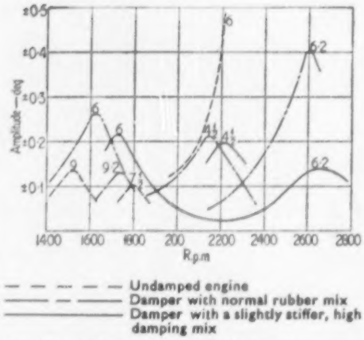


Fig. 27. Effect of crankshaft damping on a six-cylinder engine

units for instance are generally exceptionally stiff. Mountings that are too soft tend to give a poor ride on bad roads, but on the other hand, if they are too hard, fatigue failures of associated parts tend to occur.

An increasing number of manufacturers have adopted the Metacone engine mountings, probably because of their ease of installation, compactness and because they incorporate washers providing extreme travel buffers, which normally, with other types of mounting, are separate items. If properly applied, mountings of this type can be arranged to absorb the torsional vibrations about the axis of oscillation, while at the same time affording positive location of the unit against movement in the horizontal plane. If necessary, a greater degree of freedom can be given along one axis than along another at right angles to it in the plane normal to the axis of the cone. This is done by incorporating slots in the rubber on diametrically opposite sides of the unit on the axis along which flexibility is desired. A selection of conical mountings is shown in Fig. 25. Another well known engine mounting is the Metaxentric bush, Fig. 26. This type is generally fitted, with its axis horizontal in a transverse plane, at the rear of the engine-gearbox unit. In this position it provides considerable flexibility laterally, very little fore and aft, but more vertically. This is often an ideal combination of properties, especially for this application.

An article on the fundamental principles of engine mounting was published in the March, 1953, issue of *Automobile Engineer*. Since that article was prepared, an interesting mounting arrangement has been developed for the Perkins three-cylinder diesel engine. This is illustrated in Fig. 24. Two double-sandwich type units are arranged, one on each side of the flywheel housing, to absorb torsional vibrations about the longitudinal axis of oscillation. In addition, a pair of circular, double-sandwich type mountings are incorporated at the front; these, in conjunction with the sandwich type units already mentioned, absorb the rocking couples about the transverse axis of oscillation. Under the influence of these rocking couples, the

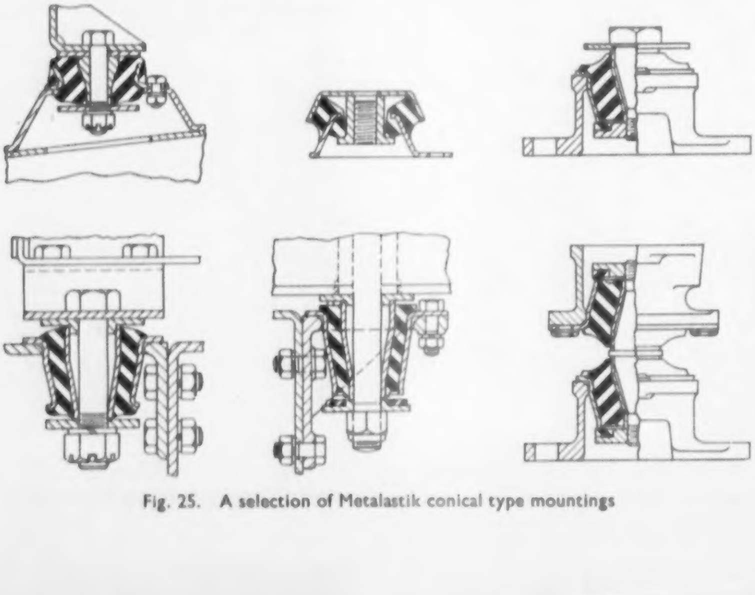


Fig. 25. A selection of Metalastik conical type mountings

movement of the relatively long extension at the rear of the gearbox tends to be excessive at certain speeds, so it is restricted by two rubber snubbers on each side.

Crankshaft torsional vibration dampers

Metalastik Ltd., have made a considerable number of crankshaft torsional vibration dampers of the tuned variety. In these an L-section rubber ring is fitted between a pressing attached to the crankshaft nose and an inertia ring. This rubber ring acts as a torsionally flexible spring. The latest development is a rubber mix that gives improved damping and high thermal conductivity. This still further reduces the amplitude of vibration without unduly high temperatures being induced in the rubber. The graph, Fig. 27, shows the amplitudes for the engine without a damper, with a damper of normal rubber mix and with an alternative unit in which the new high damping mix is employed.

For this particular engine, a six-cylinder diesel unit, it was desired to extend the running range upwards and to govern at 2,400 r.p.m. This implied designing the engine to run up to at least 2,600 r.p.m., and possibly even as much as 2,700 r.p.m. Because of the large amplitude of the vibration, $\pm 0{\cdot}5$ deg at just over 2,200 r.p.m., governing even at 2,000 r.p.m., without a damper, would have been unwise. In fact, 1,900 r.p.m. would be considered a safe governed speed. The fitting of a damper with a normal rubber mix allowed the governed speed to be increased to 2,200 or possibly 2,300 r.p.m. However, the limitation was the amplitude of vibration, $\pm 0{\cdot}4$ deg at 2,600 r.p.m. Although this amplitude was not necessarily dangerous from a crankshaft stress aspect, the engine would have been noisy.

The high damping mix was made slightly stiffer than the normal one, with the idea of reducing the high speed vibration amplitudes, that is, those of the 6th order, two-node. The employment of this mix made it possible to govern at 2,400 r.p.m. or even 2,600 r.p.m., since the limitation no longer was crankshaft torsional vibration amplitudes. It would, or course, have been possible to obtain greater reductions of the 6th and $4\frac{1}{2}$ order, one-node vibration amplitudes with a rather more flexible high-damping rubber unit, but the one with which the curves illustrated were obtained was considered better for this particular application.

SUBTLETIES OF STEERING

A Summary of the Main Problems

A NEW booklet, entitled "Subtleties of Steering," has recently been published at a price of 2s by Automotive Products Ltd., of Leamington Spa. This booklet comprises a series of articles by an acknowledged authority on the subject. These articles are based on the short treatises on steering which appeared in the Thompson steering rod assembly advertisements published in *Automobile Engineer* during 1953 and 1954. Although the booklet, as its title suggests, deals with some of the more obscure technical points of steering, it is nevertheless written in simple language and so is readily understood.

In the introductory section, it is pointed out that, when a lateral force is applied to a car, the front and rear tyres may have different drift angles. If the drift angle at the front is greater than that at the rear, the car, of course, describes a curved path and the centrifugal force is in a direction that, in general, tends to oppose the side load that is causing the deviation from the straight path. On the other hand, if the rear drift angle is the greater of the two, the centrifugal force acts in the same sense as the disturbing force and, therefore, gives rise to a tendency towards instability.

The next two sections explain how side thrust causes the slip angle and how this angle is affected by the load carried and by tyre inflation pressures. Camber angle and camber thrust are also explained. Then the booklet deals with the properties of different vehicle layouts, roll axis height and its effect on weight transference, and roll steer. The final two sections, on the causes of over- and understeer, deal in some detail with lateral loads due to camber thrust, drag, self-righting torque and other factors.

The last ten pages of this 27 page work deal with the transient stage, that is, the behaviour of a vehicle as it changes from travel in a straight line to a curved path and *vice versa*. The effects considered are the K^2/ab ratio, shock absorbers, bump and rebound buffers and roll geometry. Although this booklet, because of the relatively small space available, does not deal with the subject in great detail, it does include all the main factors relevant to steering behaviour.

INSTITUTION OF MECHANICAL ENGINEERS

Forthcoming Meetings of the Automobile Division

The following meetings will be held during December:—

LONDON

Tuesday, 13th December, 5.30 p.m., at 1 Birdcage Walk, Westminster, S.W.1. General Meeting. Paper: "Some Notes on Carburation and Other Fuel System Problems," by C. H. Fisher.

SCOTTISH CENTRE

Monday, 19th December, 7.30 p.m., in the Institution of Engineers and Shipbuilders, 39 Elmbank Crescent, Glasgow. Paper: "Heat Losses in I.C. Engines," by A. S. Leah, Ph.D., B.Sc.

WESTERN CENTRE

Thursday, 15th December, 6.45 p.m., in Fortes Restaurant, Bath. Paper: "Rubber Suspensions," by Alex Moulton.

The following meetings will be held during January:—

LONDON

Tuesday, 10th January, 5.30 p.m., at 1 Birdcage Walk, Westminster, S.W.1. Paper: "Overdrives," by S. H. Ashby.

COVENTRY CENTRE

Tuesday, 5th January, 7.15 p.m., in the Grosvenor Room, Leofric Hotel, Coventry. Paper: "Overdrives," by S. H. Ashby.

LUTON CENTRE

Monday, 9th January, 7.30 p.m., in the Assembly Hall, Luton Town Hall. Address by the Chairman of the Automobile Division, Dr. C. G. Williams, M.I.Mech.E., entitled "Some Experiences of Automobile Research."

SCOTTISH CENTRE

Monday, 16th January, 7.30 p.m., in the Institution of Engineers and Shipbuilders, 39 Elmbank Crescent, Glasgow. Paper: "Brakes Usage under Service Conditions," by N. Carpenter, A.M.I.Mech.E.

NORTH-EASTERN CENTRE

Wednesday, 18th January, 7.30 p.m., in the Chemistry Lecture Theatre, The University, Leeds. Address by the Chairman of the Automobile Division, Dr. C. G. Williams, M.I.Mech.E., entitled "Some Experiences of Automobile Research."

CORROSION OF CAR BODIES

A Résumé of American Investigations

J. A. Edwards

ACCORDING to the American Automobile Manufacturer's Association, passenger cars are being scrapped at the rate of about three million per year. Except for the small number of total wrecks, nearly all have rusted beyond economic repair. The average of life of cars scrapped in 1925 was 6½ years, while that of vehicles scrapped in 1951 had increased to 13½ years. Longer life was primarily the result of improved engines and other mechanical parts. There has, however, been little significant improvement in the resistance of sheet steel used in motor car manufacture to corrosion.

A paper presented recently before the Society of Automobile Engineers by J. C. Holzwarth, R. F. Thomson and A. L. Boegehold, all of General Motors Corporation, discussed some recent observations on the rusting of low-alloy steels in car bodies and other environments. This gives some new information on the nature of body corrosion failure, and may ultimately lead the way to the development of a better steel, or stimulate new ideas for improving design and protective coatings.

Corrosion of motor car bodies is generally divided into two types. (1) That which causes unsightly discoloration of exterior body surfaces where protective finishes have been chipped or abraded and (2) that which causes rapid deterioration and perforation of body components. The first type of rust, though a nuisance, is usually conspicuous during its early formation and may therefore be readily controlled by conventional methods of polishing, waxing and painting. The second type is more insidious, as it occurs most often in sheltered areas such as interiors of rocker panels, inside doors and window wells, or in the underbody. In these places, rusting may remain undected until severe damage or complete perforation of the steel occurs. Furthermore, corrosion in these

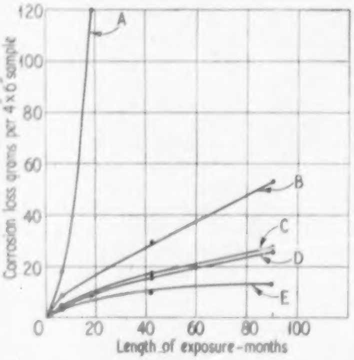


Fig. 1. Corrosion rates for various low-alloy steels exposed at 800 ft at Kure Beach, North Carolina

sheltered regions is greatly accelerated, since the rust formed is non-protective.

Several investigators have shown that corrosion extends more readily in sheltered places because the growth of a protective rust formation is retarded. The washing action of rain on steel exposed outdoors, for instance, aids protective rust formation by removing soluble corrosion products. If these are not washed away they remain in the rust and cause high porosity. In sheltered areas of car bodies, where washing action by waters is limited, the rust remains porous.

Complete and rapid drying is important in the formation of protective rusts. In the case of sheltered car body components, where the steel remains wet for long periods, the rust remains non-protective and the constant presence of moisture greatly accelerates corrosive attack. There are several methods of overcoming this difficulty. Improved design to eliminate crevices would, of course, remove the cause, but this is often inconvenient and impracticable. Likewise, continuous coating of crevices with mastic materials to protect against moisture is not always possible since the areas are often completely inaccessible.

High-strength low-alloy steels have often been recommended for use in car body construction. However, the price of these steels is one and a half that of rimmed steel, and so far there is no conclusive evidence to show that high-strength low-alloy steels have sufficiently increased resistance to corrosion to justify this increase in cost.

The present goal is the development of a cheap, readily-formed sheet steel having markedly improved resistance against sheltered corrosion. A material which corrodes at about one quarter to one half the rate of the material used at present would show the improvement required. The development of such a material requires the extensive testing of a vast number of different alloys. To accomplish this, a rapid test method is needed to eliminate the large number of low corrosion-resistant materials and select the few promising steels for further tests. Whilst service testing must be the final method of evaluating corrosion resistance, it has several disadvantages. It requires a long time to obtain results and is expensive. Such tests also do not indicate what rate of corrosion must be expected in sheltered areas.

In one test an unpainted rocker panel was exposed until failure on an outdoor rack at Kure Beach, North Carolina, 80 ft from the ocean. The openly exposed surface was covered with a fairly uniform rust. In the centre of the rocker panel, two sheets of steel overlap to form a crevice and here the steel between welds was bulged by voluminous lamellar rust. Accelerated corrosion was caused by the retention of moisture in the crevice area. The rust in this crevice was apparently less protective than that on the open surface since the steel on which the heavy rust was formed was almost completely corroded away and was perforated in spots, while the boldly exposed area of steel lost less than 10 per cent of its

TABLE I. X-RAY ANALYSIS OF RUST ASSOCIATED WITH CAR BODY SERVICE

Rust removed from	Model	Composition per cent	
		Fe_3O_4	$\alpha Fe_2O_3 \cdot H_2O$
Rocker panel	1939	80	20
Fender welt	1941	85	15
Inner door	1942	80	20
Fender welt	1942	85	15
Window welt	1942	85	15
Fender welt	1946	90	10
Rocker panel	1946	85	15

TABLE II. X-RAY ANALYSIS OF RUST PRODUCED IN OUTDOOR TESTS

Steel	Composition per cent		
	Fe_3O_4	$\alpha Fe_2O_3 \cdot H_2O$	$\gamma Fe_2O_3 \cdot H_2O$
Rimmed body sheet	None	50	50
Crevice, rimmed	85	15	None
Open hearth iron	No sample available		
Open hearth	None	50	50
High-strength low-alloy	None	40	60
SAE 2115	None	50	50
SAE 2515	None	60	40
3 per cent Cr	None	50	50

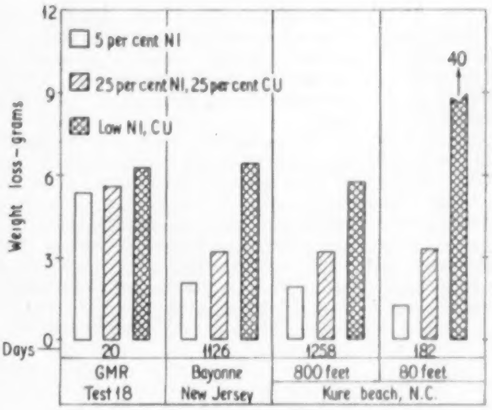


Fig. 2. Composition of General Motors cyclic humidity test and atmospheric exposure test

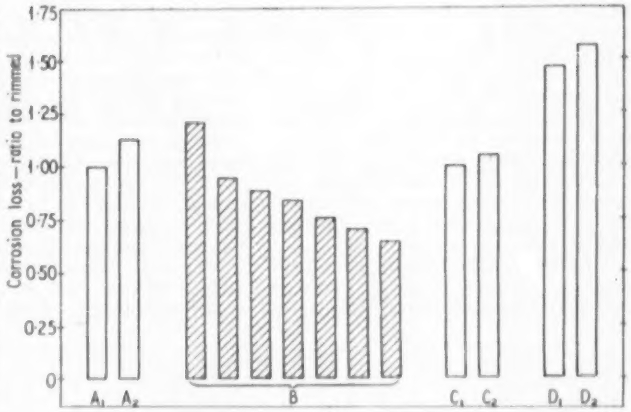


Fig. 3. Comparison of resistance to corrosion shown by various steels according to cyclic humidity test

original thickness on the average, and a maximum of 20 per cent in the area of deepest pits.

Various body components removed from scrapped cars after from 8 to 12 years' service were similarly found to be covered with heavy lamellar corrosion products on interior surfaces where protective rust formation has not taken place. A series of rust samples collected from these perforated components in the area of failure was analyzed by X-ray diffraction techniques; the results of this study are shown in Table I. Regardless of make or model the rust associated with each body failure was found to be 80 to 90 per cent Fe_3O_4 and 10 to 20 per cent $Fe_2O_3 \cdot H_2O$.

In contrast to the non-protective type of rust, the rust formed on steel sheets exposed on outdoor test racks is quite different. Figure 1 shows the corrosion rates of several steels. These rate curves, reproduced from data supplied by the corrosion engineering section of the International Nickel Company, show that steel of very moderate alloy content (open hearth steel), as well as steel of considerable alloy content (SEA 2515), forms protective rust to some degree on rack exposure. Open hearth iron, a material of very low-alloy content, was the only material which did not form a protective rust outdoors. In fact, it was discovered that all test specimens of this material had completely corroded away, so that rust samples were not available for analysis.

X-ray identification of rusts formed on available samples of these steels and on several other steels exposed at Kure Beach, North Carolina, are given in Table II. All these rusts were found to be composed entirely of Fe_2O_3 hydrates, except that which formed on the rocker panel used in an experiment described earlier. Rust formed on this was again found to be 85 per cent Fe_3O_4 and 15 per cent $Fe_2O_3 \cdot H_2O$. The presence of 85 per cent Fe_3O_4 in the crevice rust of this fabricated steel component suggests that non-protective rusts are characterized by large percentages of magnetite, while protective rusts are predominantly Fe_2O_3 hydrates.

In order to reproduce the sheltered type of corrosion, General Motors Research Laboratories developed a cyclic humidity accelerated corrosion test. The results are given in Table III. With this test, bare steel panels, suspended in a constant temperature cabinet at 125 degF, are corroded by humid air passing over them. The relative humidity of this air is cycled between 100 and about 10 per cent, each cycle requiring about eight hours. The samples are wetted once each day with a dilute salt solution. This alternate moistening and partial drying of samples in the presence of the electrolyte produces a non-protective rust. On each humidity cycle, a new layer of rust is produced under the corrosion products formed during previous cycles. As may be seen from Table III, the rust formed on car body steel by this test is nearly identical in composition and crystalline structure to corrosion products causing failure in car bodies after long service. (Table I.) Therefore, it appears that the General Motors test produces the same kind of non-protective rust in 20 days which contributes to car body failure after a number of years. Conventional outdoor tests, on the other hand, produce corrosion products which are usually, to some degree, protective.

Several steels exposed in the cyclic humidity test and on outdoor test racks are compared in Fig. 2. In 20 days this test produced the same amount of corrosion on car body steel as three years of atmospheric exposure at Bayonne, New Jersey, or 3½ years in the test at Kure Beach, North Carolina.

The General Motors test shows only small differences in weight losses between the three steels, while the outdoor tests show much greater differences. Probably the reason for this is that nickel and nickel-copper steels develop more protective rusts in atmospheric exposure tests, while, under the conditions of sheltered corrosion produced in the General Motors test, they are less capable of developing protective corrosion products.

The inability of nickel and chromium to form protective rusts under conditions of sheltered corrosion is exemplified in Fig. 3. In this chart, a number of low-alloy high strength steels, B, SAE 2115 and SA 2515 nickel-steels C_1 and C_2, and 3 per cent and 5 per cent chromium steels, D_1 and D_2, are compared with rimmed, A_1 and aluminium-killed, A_2, car body sheet. Since rimmed steel is used for 80 per cent of cars, comparison is made by ratio of corrosion loss to rimmed steel. The two alloys containing 1 and 5 per cent nickel show the same corrosion loss as rimmed steel, and no benefit can therefore be attributed to nickel

TABLE III. X-RAY ANALYSIS OF RUST PRODUCED IN 20-DAY GENERAL MOTORS CYCLIC HUMIDITY TEST

Steel	Composition per cent			Corrosion loss
	Fe_3O_4	$\alpha Fe_2O_3 \cdot H_2O$	$\gamma Fe_2O_3 \cdot H_2O$	
Rimmed car body	85	15		100
High-strength low-alloy	90	10		125
O.H. iron	85	15		173
O.H. steel	85	15		107
High-strength low-alloy	80	15	5	77
SAE 2115	90	10		105
SAE 2515	85	15		104
3 per cent Cr	85	15		140
Carburized rimmed	40	30	30	37

General Motors research test corrosion performance is expressed on the per cent corrosion weight loss with respect to the weight loss of rimmed auto body steel.

additions under the environment of this test. Chromium additions of up to 5 per cent actually increased corrosion by as much as 50 per cent. This indicates that under conditions where protective rust formation is retarded, small additions of chromium to low-alloy steels may actually be harmful. Incidentally, steels containing 16 per cent or more of chromium show almost no corrosion in the 20-day General Motors test.

The best of the high-strength low-alloy steels showed about 35 per cent less corrosion than rimmed steel in the General Motors test. At a price increase of 50 per cent this small improvement can hardly be justified. Although these steels show better qualities in outdoor exposure than unalloyed steels, they generally tend to form porous, lamellar non-protective rusts in the General Motors test.

Carbon, which contributes no noticeable improvement in outdoor tests, has been found to be the most potent element in reducing corrosion according to the cyclic humidity test. Two car body materials and a typical high strength low-alloy steel, each containing about 0·10 per cent carbon, were gas carburized to about 1 per cent carbon. Each material showed a decrease of more than 50 per cent in corrosion due to the carburizing treatment.

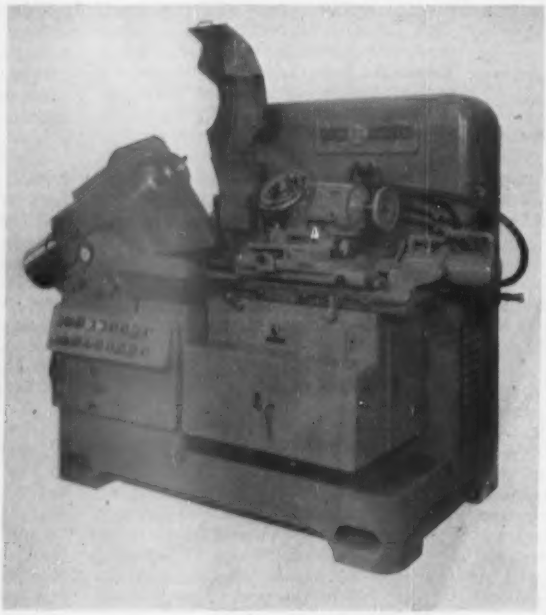
Unfortunately, high-carbon steels cannot be used for car bodies because of their poor forming characteristics. Present work is therefore being directed toward finding an additive or combination of elements which, like carbon, will produce increased resistance to sheltered corrosion at a low cost, but not affect forming characteristics.

INTERNAL GEAR SHAVING

An Interesting American Development

A NEW and versatile internal gear shaving machine, the "Red Ring Model GCR," has been developed by the American Broach and Machine Company for shaving gears to closer tolerances at greater rates of output. Essentially, this machine has been developed to meet three needs: greater precision in shaving internal gears; a wider range of application; and greater ease of operation. In short, it is designed to produce better gears at lower cost.

This machine will shave all spur or helical internal gears from 3 in to 12 in P.D. up to 4 diametral pitch and up to 2½ in face width. It operates on an automatic and selective feed cycle, and in addition to its suitability for conventional shaving, provision is made for using a new rapid plunge cut shaving cycle. Furthermore, the machine has been designed to reduce idle time for loading and unloading to a minimum.



Red Ring Model GCR internal gear shaver

The axes of the cutter and work gear are set in accordance with the crossed axes principle of gear shaving. In the shaving position, the work drives the cutter. Except in plunge cut shaving, the cutter is reciprocated across the face of the work gear teeth. In conventional shaving, as each reciprocal stroke is completed, the cutter is fed one increment into the work, unless a dwell is desired. Feed and reciprocation during the shaving cycle are both actuated by precision lead screw.

For plunge cut shaving the cutter must be at least as wide as the work gear and must be serrated differentially. In this type of shaving neither the cutter nor the work gear is reciprocated. The cutter is fed into the work in increments down to full depth. It is then allowed to idle at full depth for a number of revolutions before it is automatically withdrawn.

To facilitate the loading of wide face gears and gears with integral shafts, the machine has a pivoted workhead, which swings to 30 deg above the horizontal shaving position. The pivoting action and locking are pneumatically actuated. They are also interlocked with the cutter controls to eliminate the possibility of cutter damage. For taper shaving, the workhead may be locked in positions up to 1½ deg above or below horizontal. The workhead spindle is driven by its own motor through worm gearing and change gears. Any type of manual or air-operated workholding device may be used.

With the work gear clamped in the shaving position, the cutter slide is rapidly advanced by means of a pneumatic cylinder to a point just short of contact between cutter and work. Meshing is effected by means of a handwheel on the front of the machine, while the cutter is indexed by a handwheel at the right of the cutter spindle. Generally, the indexing handwheel need not be used, since the lead-in incorporated in the cutter will auomatically mesh the cutter with the work. On completion of the shaving cycle, the pneumatic cylinder retracts the cutter slide to the unloading position.

To accommodate the desired crossed axes setting, the cutter spindle axis can be swung 15 deg on either side of the centre. A selected number of cutting strokes may be used, with or without a selected number of idling strokes. Up-feed of any selected amount can be used, under complete automatic control, for each individual cutting stroke. At the end of the cycle, the cutter automatically returns to the correct position for unloading and reloading.

When up-feed is completely automatic, there is no danger of faulty work through errors on the part of the operator. The amount and accuracy of up-feed is governed by a master cam which serves as a stepped gauging device. Two such cams, similar except for the amount of feed increments, are included on the sequence plate of the feed unit. Each knee movement so controlled is fast, positive and precise.

The up-feed control mechanism is housed in a closed cabinet at the front of the knee. An observation window allows the operator to read a circular scale which indicates the amount of up-feed for each cutting stroke. To prevent unauthorized changes in the shaving cycle, the cabinet may be locked.

MAINS FREQUENCY INDUCTION HEATING

Wild-Barfield Automatic Billet Heaters for the Production Line

ALTHOUGH the use of mains frequency induction heating has been established for some considerable time, particularly for the melting of aluminium and light alloys, the range of applications of the system has been notably extended in recent years. For the rapid heating of non-ferrous alloy billets prior to extruding or forging operations, mains frequency induction heating has been proved to be eminently suitable. Already it has been used for billets of diameters ranging from 2 in to 12 in diameter. The method is not confined solely to light alloy billets, however, and provided the billet is of an adequate diameter, other metals can be treated. For the following materials, heated to the usual working temperatures, aluminium alloys (500 deg C), aluminium bronze (950 deg C), brass (950 deg C), copper (1,000 deg C) and steel (700 deg C), the minimum practical billet diameters are 2in, 4 in, 3 in, 2 in and 1½ in respectively.

A small Wild-Barfield mains frequency billet heater is shown in Fig. 1. This was specifically constructed as a working unit to demonstrate the general principle and the method of operation common to automatic induction heaters for billets of all sizes. In Fig. 2, the operating section is shown set up for demonstration and with the covers removed. The billets are loaded side-by-side on an inclined ramp or chute at one side of the unit, and a solenoid-operated pusher rod propels one billet at a time into the inductor mounted within the casing. At the same time, a second solenoid, shown on the left of the illustration, moves a spring-loaded thermocouple into contact with the end face of the billet and, simultaneously, the heating current is switched on.

As soon as the billet has attained the desired temperature, the thermocouple operates the automatic temperature controller, which cuts off the heating current. A solenoid-operated ejector projects the heated billet from the inductor on to a second inclined chute and it is discharged to the opposite side of the unit. The next billet is then loaded into the inductor and the cycle repeated. On the small demonstration model, Fig. 1, aluminium billets 2¼ in diameter and 2¼ in long are heated from room temperature to 500-550 deg C in 40 seconds. This

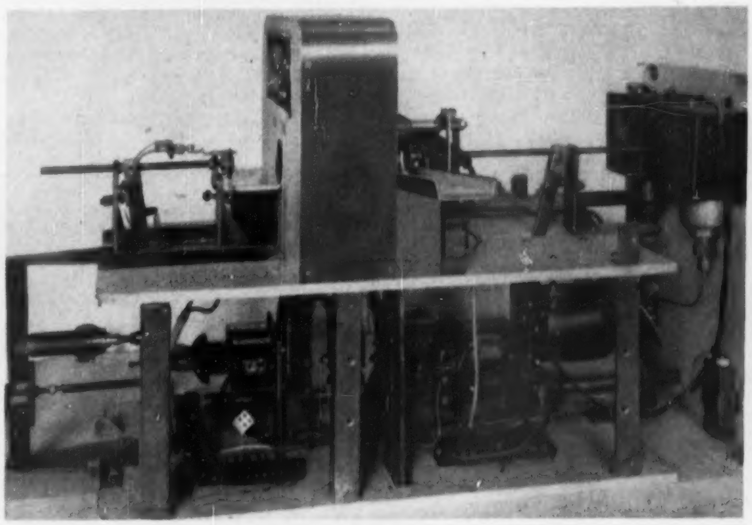


Fig. 2. Operating section of demonstration unit on rig with covers removed

Fig. 1. Small demonstration model mains frequency automatic billet heater

Fig. 3. Main frequency equipment for automatically heating metal rings

represents an output of from 65 to 75 lb/hr.

Billet heaters for large-scale production would be constructed to handle several billets simultaneously, thus increasing the rate of output. On such production machines, the various mechanisms would be actuated by pneumatic equipment rather than by the solenoids employed in this small demonstration model.

Another application of mains frequency induction heating is exemplified by the equipment shown in Fig. 3. This machine is used to preheat copper rings and is of a design differing radically from that commonly employed for this purpose. Such equipments are usually arranged so that the ring is utilized to form the short-circuited turn of a closed magnetic circuit transformer. Consequently, it is necessary to break this magnetic circuit in order to load the ring and to close the circuit again before switching on the heating current. In the Wild-Barfield machine, the ring is loaded into an open inductor, and an automatic operation then clamps it in position and at the same time switches on the current. The unloading of the heated ring and its delivery to the operator are also automatic, these operations being effected by pneumatic actuators.

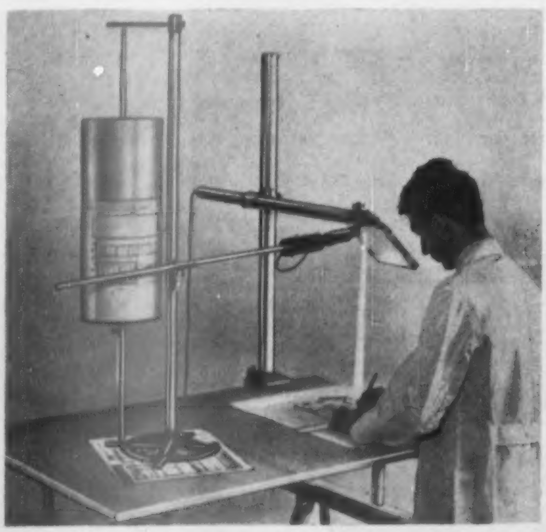
These two applications are merely typical and are not intended to indicate the limits of either the range of induction heaters or of the field of applications covered. Mains frequency induction heaters can bring a number of advantages to such operations as billet heating. These may be summarized as follows:

1. The maximum temperature acquired by any part of the equipment does not exceed that of the work being treated.
2. Excellent thermal response to automatic controls eliminates any tendency to overshoot on work temperature, with resulting accuracy and consistency of treatments.
3. Billet heating equipments occupy the minimum of floor space and can be arranged for continuous operation. They can thus be incorporated without difficulty in a production line.
4. A valuable characteristic is the rapid rate of heating. No time is lost in bringing the equipment up to operating temperature and, conversely, little energy is dissipated in cooling off when the equipment is shut down at night or at week-ends.
5. Any necessary maintenance can be carried out or adjustments made immediately after switching off.

THE PERSPEKTIV-AUTOMAT

IN instruction manuals and maintenance handbooks increasing use is made of perspective drawings. In the workshop also, since the wartime introduction of personnel lacking technical training and ability to "read" conventional drawings, the perspective drawing is proving of value in some instances. Particularly in assembly operations a perspective view can often usefully supplement, if not supplant, an orthodox general assembly drawing. Project and styling departments also use perspective drawings for the ready visualization by managements of new schemes or designs.

The production of a perspective drawing is a relatively lengthy process and calls for the exercise of highly specialized skill and a measure of artistic perception. Various schemes to lower the cost and reduce the time required by substituting three-dimensional drawings at standardized projection angles fail to achieve their object completely owing to technical or artistic shortcomings. With the aid of this Swiss-built optical projection instrument, however, true perspective drawings can be produced from ordinary workshop drawings without the need for exceptional skill or an undue expenditure of time.



In use the Perspektiv-Automat permits unobstructed access to the paper on the drawing table

The apparatus comprises a vertical column, 39 in high, which is securely clamped to one edge of the drawing table. To this is clamped a horizontal tube, 35½ in long, adjustment being possible over the entire length of both vertical and horizontal elements. On the end of the horizontal tube is adjustably mounted the crystal glass silver-backed reflecting mirror. A movable stand, 43 in high, carries a freely revolvable cylinder of opaque Perspex, 19½in high and 33 in circumference, which can be set at any height on its axis

Linking the fixed and the movable columns is the projector carrier tube, universally jointed to the horizontal tube adjacent to the mirror clamp and lightly resting and slidable on a universally jointed slipper block adjustably clamped on the movable stand column. In the projector is a 6V, 5A bulb, the light from which passes a condenser, a reticle, and a projection lens to throw an image of the reticle on to the mirror which reflects it, in a circle of light, on to the drawing paper. Mounted in the base of the movable stand is a second reticle in precise vertical alignment with the intersecting axes of the projector carrier tube and the slipper block universal joint.

The observation point (the point at which the projected light meets the mirror) can be selected with complete freedom. Angles, heights and distances can be varied at will by adjustment of the relative position of component parts. The drawing paper and the plan view, at the selected angle of observation, are affixed to the drawing board by adhesive tape, and the elevation is similarly attached to the revolvable cylinder.

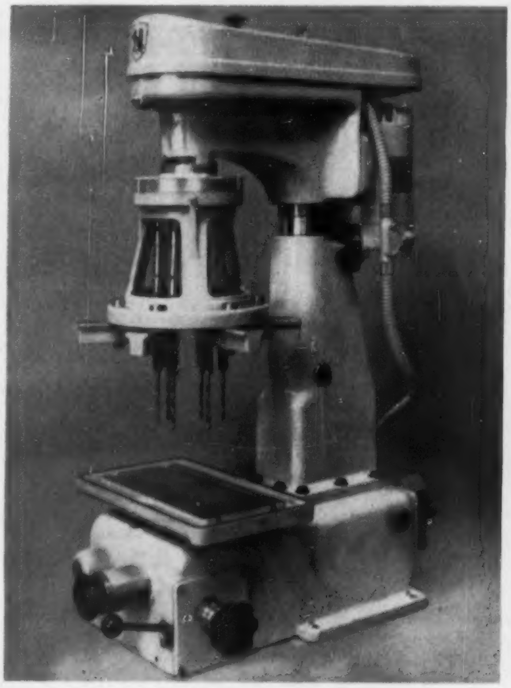
If the perspective drawing is to approximate the ratio of 1 : 1 to the original drawings, the distances of the observation point on the mirror from the drawing paper and from the slipper block on the movable stand should be about equal.

The draughtsman then selects a level on the elevation and, with the left hand, slides the movable stand over the plan until the reticle in the base registers over a point at this level. This point is mirror-reflected and, using the right hand, is marked on the drawing paper. Successive points at that level are marked and connected and then the slipper block is moved to another level and the procedure is repeated until all necessary points are marked. Curves can be divided into points by means of lined or squared transparent sheets which are laid over the plan. The instrument is supplied, complete with a 6 V 7 A transformer for the lighting, and two transparencies, by W. G. Pinner & Co., 1 York Road, Birmingham.

MULTIPLE DRILLING

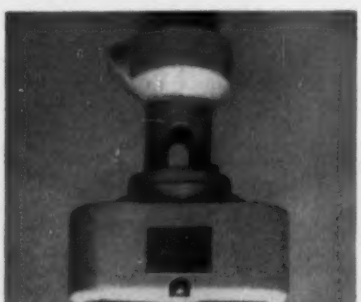
High Production and Automatic Operation on Small Components

POSSIBLY because of its apparent simplicity, the drilling of small size component parts is frequently carried out with the simplest tools and relatively elementary jigging equipment. However, production rates can be materially increased by multiple drilling and the use of simple, manually indexed, multi-station jigs, even on runs of only moderate length. If operation of the drill press is mechanized the work can be done by female operatives. For long production runs, the indexing can also be mechanized and cycled with the press actuation to give automatic operation. The operative is then required merely to load and unload the work.



Pneumatically operated drilling machine, Type MA1, with adjustable centre multi-spindle head

In addition to the production of large multiple drilling heads for special purpose machines for major components such as cylinder blocks, cylinder heads, transmission casings, axle casings and the like, a range of small standardized heads is also built by Slack and Parr, Ltd., of Kegworth, near Derby. These are of various types and number of spindles and can be fitted to any existing standard drilling machine. With the exception of the larger adjustable centre head they are also interchangeably embodied in the high-production bench machines with hydro-pneumatic feed that are produced by the firm specially for this work. A high degree of standardization, and the interchangeability of standard parts, makes possible a rapid spares service and minimizes loss of production arising from normal maintenance.



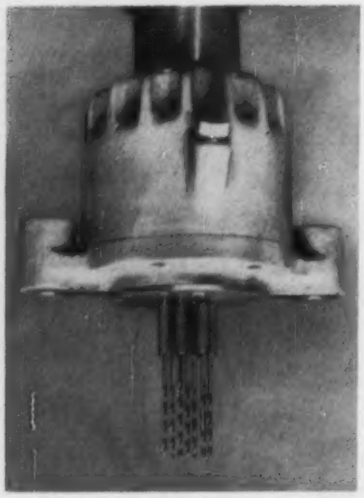
Adjustable geared head; three equally spaced and aligned holes

Units of the adjustable centre type are made in two sizes. The larger, Type A88, has eight spindles for No. 1 Morse taper drills, to a maximum of $\frac{5}{8}$ in diameter for mild steel, and requires as a maximum a 3·5 h.p. driving motor. Holes can be drilled to a maximum circle of 8 in and the minimum centre distance is 1 in. Six spindles are provided on the smaller unit, Type A66, which can be set to drill up to a 6 in diameter circle and down to $\frac{11}{16}$ in centre distances. Drills are held in collets, the maximum capacity being $\frac{1}{4}$ in, but $\frac{3}{16}$ in is stipulated for mild steel. A driving motor of 1·5 h.p. is specified.

As standard the A88 head has an output:input ratio of 1·41:1 and the A66 head a ratio of 1:1. The reason for the speed-up in the case of the larger unit is that, in order to obtain sufficient power, it is often necessary to use it on a large drilling machine on which the speeds and feeds are more suitable to larger diameter drills. By increasing the spindle speed, therefore, a more correct drilling speed for small diameter drills is obtained and simultaneously the rate of feed per revolution is reduced. Where specifically required, as for instance when tapping operations are also to be performed, the A88 head can be supplied with a 1:1 ratio.

Produced to meet the requirements of small batch production, both units are of similar design, differing only in the drill spindle thrust arrangements. In the smaller head the thrust is taken on flanged Oilite bushes but ball thrust races are provided on the larger unit. The casing is of light alloy in order to keep down the weight so that the unit can safely be supported on a standard drilling machine by a quill clamp gripped by means of a pinch bolt. On the firm's own drilling machines the casing is registered and bolted directly to the headstock. From the machine spindle the drive is taken by a taper shank having a tanged end which is engaged in the end of the central driving gear spindle. Thence the drive is transmitted by idler gears to the driven gears and by telescoping shafts, with a Mollart universal joint at each end, to the drill spindles. Driving and driven gears are each mounted in an upper Oilite bushing and a lower ball bearing, while idler gears are in a pair of bushes. Grease lubrication is provided for the drive gears and replenishment is effected through a nipple in

Adjustable geared head; four holes equally spaced on pitch circle



Closely pitched 7-spindle gearless head

the casing. Each spindle runs in a pair of bushes in the contoured end of of a slotted support arm secured to the casting lower face by a single bolt. Apart from the limitation of minimum centre distance, there is no restriction on the hole pattern within the maximum drilling circle. The simple, one-bolt adjustment of spindle position makes possible a rapid changeover between batches of work.

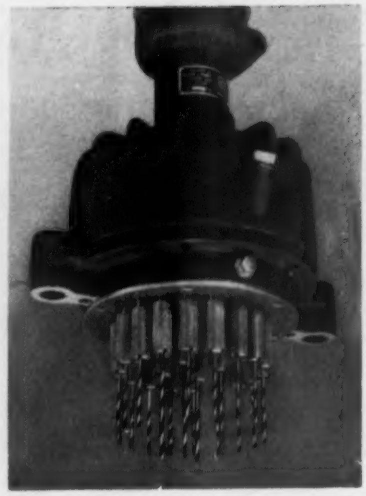
In addition to normal through drilling, countersinking, counterboring, spot-facing, reaming and tapping can be undertaken. To facilitate the setting for the production of blind holes, individual adjustment of spindle height to the extent of 1 in is provided on the A88 head. It is desirable to employ pitch control in tapping operations, and especially so where multi-tapping is undertaken. In such cases the multi-spindle heads are used either on a tapping machine equipped with pitch control or on a drilling machine having the correct rate of feed to obtain the required pitch.

Another range of standard geared heads gives simple adjustment to a single holt pattern. There are two-, three-, and four-spindle units, all having a maximum collet capacity of ¼ in. In the two-spindle head, both spindles are adjustable to vary the centre-to-centre distance from ⅞ in to 4⅜ in. It has a No. 2 Morse taper drive shank for mounting directly in the machine spindle and does not need a quill clamp. A radially adjustable torque arm is used to maintain the head in the desired working position. The output : input speed ratio is 1·16:1·0, and ⅓ h.p. is required to drive.

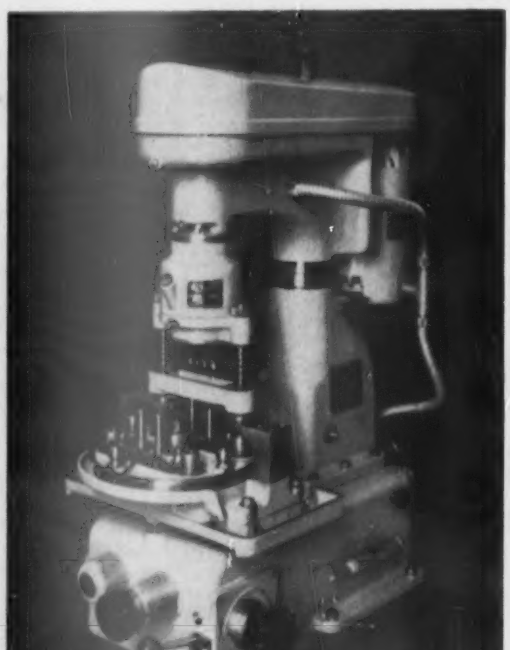
The other models are attached by a quill clamp, as previously described. Two three-spindle models can be arranged with Nos. 1, 2, or 3 Morse taper driving tangs, and need ¼ h.p. to drive. In one of these the centre spindle is fixed and the other two adjustable to give three holes equally spaced in line. The major centre distance ranges from 1¾ in to 5¼ in. All spindles are adjustable in the second model to give three holes equally pitched on circles varying from 1¾ in to 5¼ in diameter. Output:input speed ratios are 1:1 and 2:1 respectively. Similarly, the four-spindle model is for equally pitched holes on circles of from 2 in to 5½ in. Driving tangs may be either No. 2 or No. 3 Morse taper and the output:input ratio is 1·7:1.

All are built up from standardized components to minimize costs. The driving gear is mounted on opposed angular-contact ball bearings, and drill spindles are in phosphor bronze bushings and are grease lubricated by a pressure gun. Drill thrust is taken by a ball thrust race on each spindle end. Drill spacing is changed by partial rotation of the spindle housing and reclamping in the adjusted position. Spring collets for straight shank drills are fitted to the spindles.

Fixed centre drill heads, produced to meet specific requirements, are of two types, gearless or gear driven. Gearless units necessarily have an input:output ratio of 1:1 for all spindles but on the geared type each spindle is individually driven and drills of different size or other tools are rotated at their appropriate cutting speeds. In the gearless heads the driving shaft, mounted in two ball bearings, carries a relatively heavy and suitably counterbalanced flywheel having an offset bearing in its lower face. Engaged in this bearing is the spindle of the circular driving plate which transmits the motion to the pins of the cranked drill spindles. Each spindle pin runs in needle roller bearings in the driving plate and drill thrust is taken from the end of the pin by a ball thrust race. Where the drill pattern will permit, the spindles run in phosphor bronze bushes in a light alloy housing, but where bushing is precluded by close pitching of the holes, the complete spindle housing is of phosphor bronze.



Gearless head with 22 spindles



MF1 drilling machine with gearless head and manually indexing 2-station jig

These gearless units can be produced with any drill pattern, no matter how elaborate. They are suitable for the drilling of holes up to a maximum of ¼ in. diameter and centre distances can be as low as twice the drill diameter. A common application is for "flash" clearances in die castings or plastics mouldings. Spring collets are used for straight shank drills. Spindles are produced in three sizes for drills to 3/32 in, 3/16 in and ¼ in diameter and minimum centre distances of ¼ in, ⅜ in and ½ in respectively. All are standardized in lengths varying by increments of ¼ in, and by selection it is possible to cater for different drills and hole depths, and to use the largest diameter spindle the hole centres will allow. Alternative spindles are available for Morse taper shank drills or with a Jacob's taper for a drill chuck.

The driving plate is immersed in oil and from the casing a metered supply is fed to a reservoir plate secured to the outer face of the spindle housing. From there it is lifted back to the casing by way of

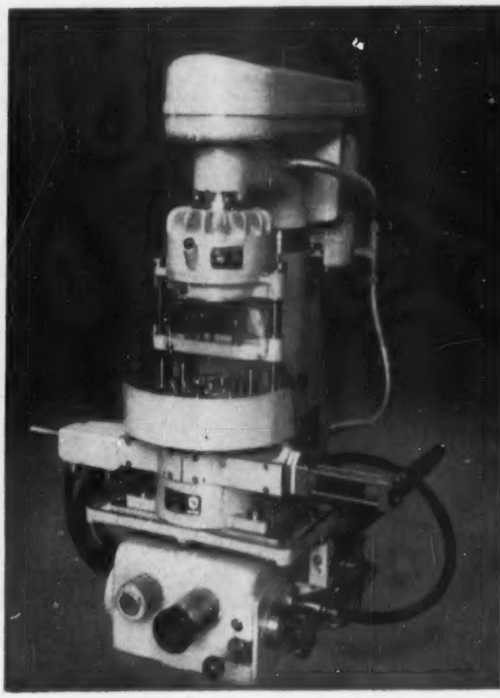
helical grooves in the spindle bearings. Guide bars are desirable to ensure alignment with the drill jig and to minimize drill breakage. As standard, two diametrically opposite bushed bosses are provided on the spindle housing for this purpose, but special locations can be arranged where necessary.

Fixed centre geared heads embody all the customary features of the large heads employed on special production line equipment. From the central driving gear, idler gears transmit the drive to the spindle gears. By selection, an assembly of standardized gears, driving, idling, and driven, can provide a wide range of individual spindle ratios. Spindles are mounted in ball races throughout, the only exceptions being in instances were a close centre-to-centre distance enforces the use of plain bushings. The light alloy casing, bossed and bushed for guide bars, serves as an oil bath for the gears and leakage from the spindles is prevented by synthetic rubber oil seals. Where bearings are positioned above the oil level, automatic lubrication is incorporated in the design. Individual vertical adjustment of the spindles, which normally are bored to receive Morse taper shank drills, can be provided if desired. Standard spindles are available for up to No. 5 M.T. drills. Attachment is by a quill clamp or a flange, as with the other heads.

Two bench drilling machines specifically designed for use with these multiple heads are available, differing only in respect of column height to accommodate either the adjustable centre or fixed centre gearless types of heads. Base dimensions are 20 in × 13 in and overall heights are 39 in and 34 in respectively. They are suitable for either small or large batch production and the time necessary for changeover between batches, either adjustment of drill centres or the substitution of another head, can be made in a few minutes.

The cast iron headstock has a flanged spindle housing to which the drill head is accurately located and bolted. Drive to the head is from a spindle mounted in ball bearings and having a tanged end to engage directly the slotted end of the drill head driving spindle. The machine spindle is driven by a vee belt, totally enclosed in a detachable light alloy casing, from a 1 h.p. motor running at 1,450 r.p.m. and mounted at the rear of the headstock. Cone pulleys furnish a choice of three spindle speeds: 1,090, 1,450 and 1,930 r.p.m. "Stop" and "Start" push buttons are built into the headstock. Variation of the height of the headstock is by means of a jack-screw through the pillar and a hand-operated pad bolt locks it in the adjusted position. The throat of the machine is $6\frac{3}{4}$ in.

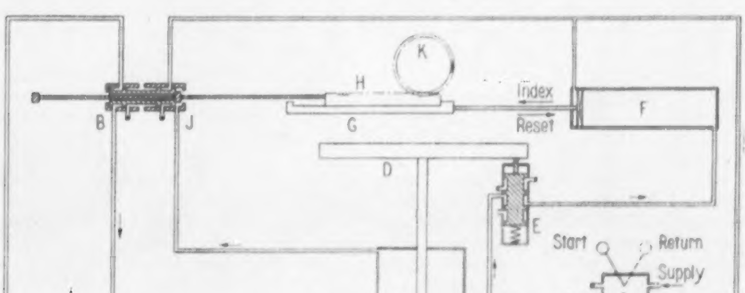
Housed in the cast iron base is the hydro-pneumatic equipment and the necessary gearing for the 12 in × 6 in T-slotted table. Gears are lubricated by an oil bath and other working parts by means of a grease gun. The table control and the feed regulator are conveniently positioned at the right-hand front of the base, while the direct-on starter is at the rear. Two handwheels on the right of the base enable the rapid-approach control and the length of the stroke to be adjusted. Possible movement of the table is 2 in and holes can be drilled to a depth of $1\frac{1}{2}$ in. On the larger machine equipped with the A66 adjustable centre head, the maximum and minimum distances between the table and the ends of the drill spindles are 10 in and 5 in respectively.



Machine equipped with 8-spindle gearless head and pneumatically operated 3-station indexing fixture

Actuation of the table is by a hydro-pneumatic system to give a semi-automatic cycle comprising a rapid approach, a feed stroke, and a quick return. Manual operation of the table control lever admits air to a Lang power cylinder and, through a rack and pinion gearing, the table is raised rapidly. When a predetermined height is reached the approach control brings a Lang hydraulic cylinder into action to control the feed stroke. The rate of feed is steplessly variable by means of the regulator which governs the rate of oil flow from the control cylinder. At the same time, oil is by-passed in the opposite direction to provide a quick return of the table when the table control is automatically released by a trip device. Lubrication of the power feed equipment is by means of a Norgren oil-fog lubricator in the power line.

Illustrations show typical examples of these machines equipped with gearless fixed centre heads and set up with indexing jigs. In the simpler, two-station, fixture the rotatable jig table is turned by hand through 180 deg to bring the work to the operational position. While at that station the work is being drilled, at the other station the finished work is unloaded and the fixture immediately reloaded ready to repeat the cycle. Automatic indexing is provided for the more elaborate three-station jig on the other machine. Using an eight-spindle head, two 0·120 in diameter holes are drilled in the workpiece, the holes are countersunk at both ends and finally they are reamed 0·125 in diameter to finish. The work is stud-located in pairs on



A—Control valve; B—Table feed valve; C—Machine cylinder; D—Machine table; E—Cycle valve; F—Indexing cylinder; G—Cam; H—Rack; J—Table return valve; K—Ratchet pinion

Diagrammatic arrangement of 3-station indexing equipment

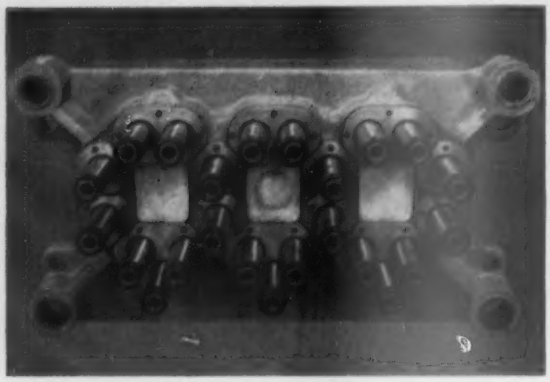
the indexing table and makes two revolutions to complete. After loading, a workpiece is drilled; countersunk; unloaded, inverted and reloaded in the adjacent advanced position; countersunk; reamed; and unloaded. Thus, at each indexing, the operator unloads one finished component, inverts and repositions a part-finished piece, and loads the next blank in the vacated position. Operation is effected by a Martonair cylinder reciprocating a rack engaged on a pinion fitted with a ratchet device to give a uni-directional intermittent rotation to the jig table.

The operational diagram shows the indexing mechanism at the point where the indexing movement has been completed and air is passing through control valve A and through valve B to cylinder C which is lifting the machine table D. As the table rises it releases valve E which cuts the air supply to the indexing cylinder F and also exhausts that cylinder. When the machine table reaches its predetermined highest point for drilling, the machine automatically trips valve A and returns the hand lever to the "return" position.

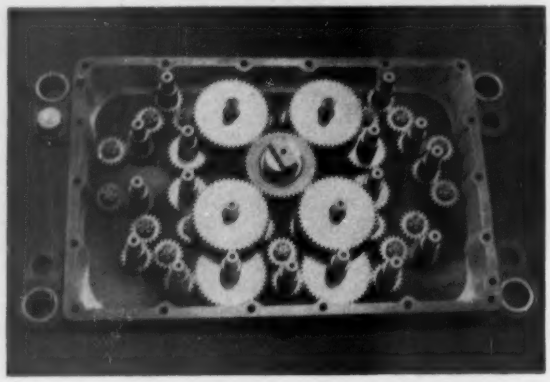
Air then passes through valve A to the left-hand end of cylinder F which moves cam G and rack H to the right or "reset" position. As it nears the end of its travel, the rack moves valves B and J to the right and air then passes through valves A and J to the upper end of cylinder C to return the table D. Approaching its lowest position the table opens valve E and stops the machine at the completion of the drilling cycle.

To re-commence the cycle, the hand lever is moved to the "start" position and air passes through valve A and valve E to cylinder F, first moving cam G to the left. Cam G withdraws a spring-loaded plunger which locked the indexing table and then moves rack H to index the table to a new position. At the end of its travel, rack H moves valves B and J to the position shown on the diagram, completing the indexing cycle.

By the addition of a pneumatic valve and a cylinder the cycle can be made to repeat automatically. This method is usually applied only in cases where a hopper feed can be used. Under the more common conditions of manual loading, the semi-automatic cycle is to be preferred in the interests of safety to both operator and machine.



Geared, fixed centre, 23-spindle head



Interior gearing of 23-spindle unit

THE PAINTING OF STRUCTURAL STEELWORK

A NOT inconsiderable item of the inconspicuous overhead charges that add to the cost of production is the maintenance of the structural steelwork of buildings and outdoor equipment. In the past the painting of steelwork received scant attention and the common practice was to cover a new erection with a red lead primer and to follow with a top coat of any paint that happened to be available. Rising costs have made such a policy progressively uneconomic and a more scientific approach has become essential.

To assess the relative values of protective schemes is not easy and cannot be effected rapidly. The British Iron and Steel Research Association and the British paint industry cooperated in four long-term investigations, commencing in 1945. These involved priming paints, protective paints based on tars or bitumens, metallic coatings, and methods of surface preparation.

Many hundreds of mild steel test plates were exposed on two sites. At Brixham a mild seaside atmosphere prevails and at Derby is a severely corrosive industrial atmosphere. Bare steel corrodes about three times as quickly at Derby than at Brixham but, in contrast, the rate of paint breakdown is more rapid at Brixham as a consequence of the longer periods of sunshine there. These investigations have begun to yield interesting results. Twenty of the pigmented priming paints under test gave better protection than the conventional red lead in linseed oil paint. All contained 20 per cent by weight of asbestine, and a marked superiority was shown by those in linseed oil medium A1, which formed a thicker film than paints in synthetic media.

Of the paints pigmented with metallic powders, those containing aluminium powders were better than those including zinc powders. The aluminium paints were in alkyd medium B1, with basic lead sulphate or zinc oxide as a blending agent. They are lighter, more stable, flow more readily, dry more quickly and form a harder film than the usual red lead primer. If zinc oxide is the blending agent they are non-toxic and can be applied by spraying.

Nine varieties of metallic coatings were tested. Aluminium and zinc coatings 3 mils thick were each better than the familiar hot-dipped terne coating 1 mil thick. As neither aluminium or zinc coated specimens had failed by rusting to any significant extent after six years' exposure, it is not yet possible to assess their relative merits. Paint flaking from hot-dipped zinc coatings was eliminated by the use of proprietary phosphating processes.

Tar and bitumen paints in five categories to a total of 54 varieties were investigated. Most gave results that were generally inferior to paints containing drying oils or synthetic resins.

The results of these researches are published in the Third Interim Report of the Joint Panel JP/1 of B.I.S.R.A., a 40-page record including tables, charts and illustrations. It presents the latest and most comprehensive information on the subject of atmospheric corrosion and can be recommended to all engineers aiming to reduce maintenance costs and prolong the life of steel structures. The report is published by the British Iron and Steel Research Association, 11 Park Lane, London, W.1, and is available, price 5s. 0d., post free.

THE OERLIKON ELECTROGYRO

Its Development and Application for Omnibus Service

STORED energy, in the form of high pressure, bottled gas or electric batteries, has been used from time to time in road vehicles. In Russia, its use has recently become more widespread as a matter of policy rather than because of direct technical advantage obtained. Battery-carrying two-wheel trailers were tried for buses in Germany, but apparently they are not a success, probably because of weight, cost and the time required to charge the batteries. The storage of mechanical energy by means of a flywheel was tried by Howell in 1870. He accelerated the wheel to 12,000 r.p.m., and in this manner stored some 375,000 ft-lb of energy, which was used to move a torpedo at 24 m.p.h. for 500 yards.[1] At about the same time, a carriage incorporating a large flywheel rotating about a horizontal axis was developed for the Czar's train, and the stored energy was used to assist the train up hills. The design was not a success because of the rigid transmission between the flywheel and driving wheels.

An arrangement for the employment of the energy of a flywheel, charged at stops by a steam engine or electric motor, was patented by Lanchester[2] in 1905. More recently, motor-generator sets incorporating flywheels have been used in the Southern Railways type Co-Co electric locomotives to move them when they stop between sections of the third rail. In 1945, the Oerlikon Engineering Company of Zurich, investigated the possibility of developing for city traffic, buses of a novel type that would offer the many advantages of electric traction, but would be capable of operation without continuous overhead supply. These investigations led to their carrying out trials with an electrically driven, energy-storing flywheel, now referred to as Electrogyro. Preliminary calculations had confirmed the feasibility of the idea, yet a considerable amount of development work along entirely novel lines was necessary before a solution, sufficiently attractive for service use, was found, Fig. 1. The main problems were the windage losses of the flywheel, the effects of the gyroscopic action of the flywheel upon the riding characteristics of the vehicle, and the provision of a cheap, simple and reliable electrical transmission between the flywheel and the road wheels.

The flywheel

The energy stored in a flywheel is proportional to the polar moment of inertia I lb-ft-sec^2 and the square of the angular velocity ω rad/sec, so:

$$E=\frac{I\omega^2}{2}$$

where $I=Mk^2$, $M=W/g$ is the flywheel mass and k its radius of gyration. For a disc of constant cross section, with r_i and r_o as the inner and outer radii respectively:

$$k^2=\left(\frac{r_o+r_i}{2}\right)^2+\left(\frac{r_o-r_i}{2}\right)^2$$

To increase the value of I as much as possible, most of the weight should be in the rim; this has been done in the Electrogyro flywheel. At the same time, care has been taken to ensure that the stress throughout the disc is uniform.

When a flywheel rotates in a housing, a certain amount of the energy is lost, because of the unavoidable disc friction or windage. This energy is transformed into heat and may appreciably increase the temperature of the surrounding fluid. The disc friction loss is due to two actions that occur simultaneously: one is the actual friction of the fluid on the disc, which is relatively small, and the second is a pumping action. This action is due to the fact that fluid in contact with the disc, or near it, is thrown outwards, by the centrifugal action, and circulates back towards the shaft as shown in Fig. 3.

The energy consumed by the disc friction depends upon the mass of the fluid that comes into contact with the disc per unit of time and the kinetic energy imparted to the fluid. In a given period of time, the mass of fluid coming into contact with the disc is proportional to the specific weight of the fluid γ, the peripheral speed of the disc u, and its area, or D^2 where D is the diameter. The kinetic energy

Fig. 1. Electrogyro vehicles in operation it Yverdon

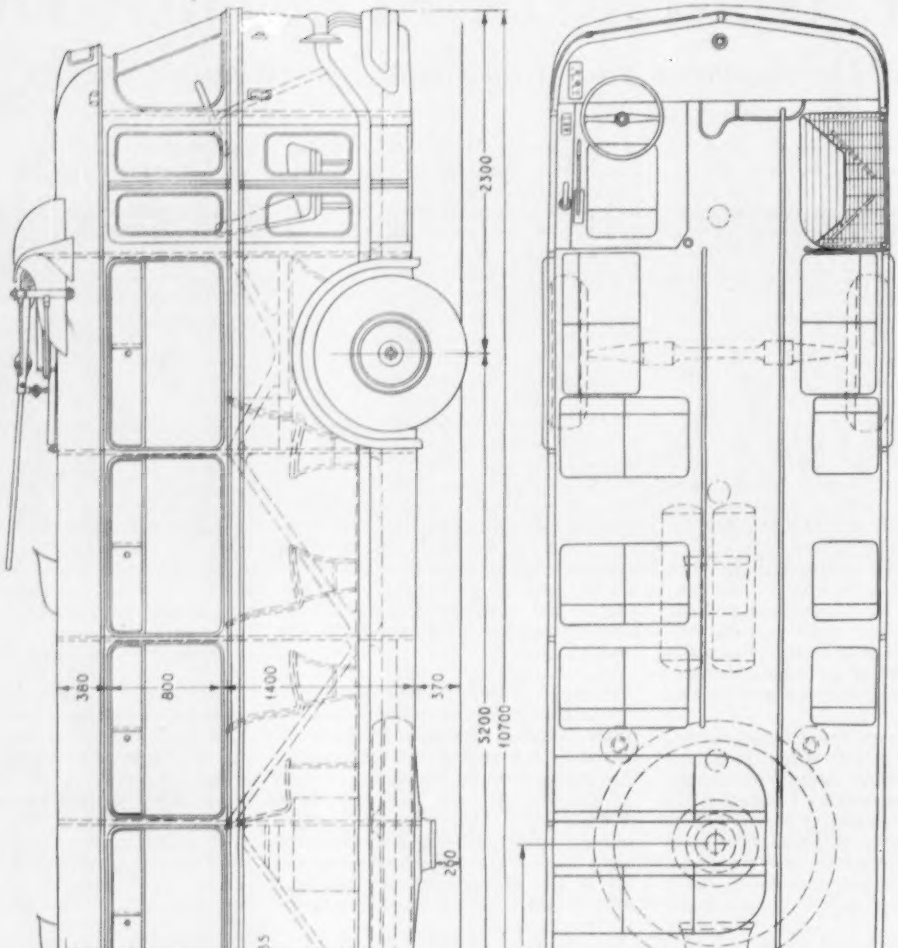


Fig. 2. LAYOUT OF THE ELECTROGYRO VEHICLE FOR GHENT SUBURBAN SERVICE
The dimensions are given in metric units

varies with the speed squared, or u^2. Hence the friction h.p. is proportional to the product of these three factors and a coefficient. That is:

Disc friction h.p. $N_f = k\gamma u^3 D^2$

However, allowance must be made for the additional loss due to the rim width e; this transforms the equation into:

$N_f = k\gamma u^3 D(D+5e)$

It is generally desirable to keep e as small as practicable; and as a mean value, $(D+5e)/D = 1{\cdot}1$ can be used for a first approximation. Consequently:

$N_f = 1{\cdot}1\ k\gamma u^3 D^2$

The value of the factor k depends on the Reynolds number $Re = uD/2\nu$. Since $u = \omega D/2$, $Re = [\omega(D/2)^2]/\nu$, where ω is the angular velocity and ν the kinematic viscosity of the fluid surrounding the disc. The values of k as derived by Pfleiderer,[3] from tests with smooth discs, and from theoretical considerations, are plotted in Fig. 3. From this, it can be seen that it is desirable to maintain a small gap, B, between the disc and housing, but it should be noted that the value of k rises again if B/D becomes smaller than about 0·012. Thus, for air at 70 degF, $\nu = 1{\cdot}64 \times 10^{-4}$ ft²/sec, so that if $D = 5$ ft and $n = 3{,}000$ r.p.m., that is, $\omega = 314$ rad/sec, $Re = 1{\cdot}2 \times 10^7$. If $B/D = 0{\cdot}015$, the value of k, obtained from Fig. 2, is $0{\cdot}78 \times 10^{-6}$ and since, for air at 70 degF, $\gamma = 0{\cdot}075$ lb/ft³, $N_f = 1{\cdot}1 \times 0{\cdot}54 \times 10^{-6} \times 0{\cdot}075 \times 785^3 \times 5^2/23{\cdot}85 = 22{\cdot}5$ h.p. The constant value of 23·85 is introduced because the units employed are ft and lb, *vis-a-vis* k determined on the basis of metric units.

This value of N_f is unduly high, despite the fact that it rapidly becomes smaller as the flywheel speed is reduced when its energy is used to drive the vehicle. The obvious remedy is to reduce either u, which for the same energy storage will mean a heavier flywheel, or γ. So far as the reduction of γ is concerned, the employment of hydrogen is attractive, since it is 14·4 times lighter than air, whilst its heat transfer coefficient is higher than that of air. On the other hand, its kinematic viscosity is some 6·6 times greater than that of air. In the example already calculated, if the housing were filled with hydrogen, Re would be $1{\cdot}82 \times 10^6$, so $k = 0{\cdot}72 \times 10^{-6}$ and consequently $N_f = 2{\cdot}08$ h.p. With the 5 ft diameter flywheel and no load, the speed theoretically would fall from 3,000 to 2,500 and 2,000 r.p.m. in 67 and 165 min respectively.

Hydrogen cooling is being increasingly adopted with turbo-generators of the highest power output. The employment of hydrogen in this application has the additional advantage that it increases the life of generator windings by reducing the oxidation of the cellulose-based insulation. Experience has confirmed that the reduction of ventilating and windage losses is of the order of 10 to 1.

With the Electrogyro, it has been found possible to reduce the losses still further by using the hydrogen at a pressure below atmospheric. This can be effected without undue difficulty, since all the rotating parts are enclosed by a common housing. In addition, the gap between flywheel and housing is kept to a minimum. A further advantage secured by the use of hydrogen is a more effective disposal of heat losses due to flywheel windage as well as to motor-generator losses. This is because the mean value of the heat transfer coefficient is approximately 1·7 times that for air although, because of changes in the flow conditions, it varies with different configurations.

Effect on suspension

To obtain good riding qualities, a

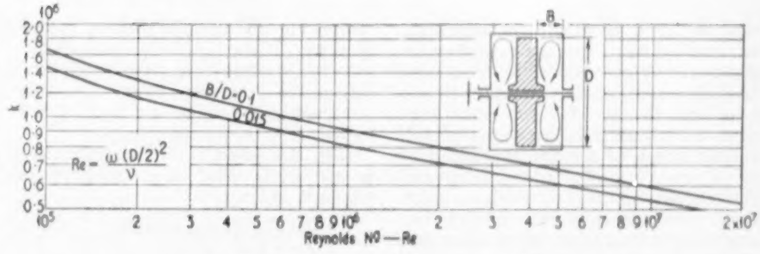


Fig. 3. Effect of flywheel clearance on windage losses

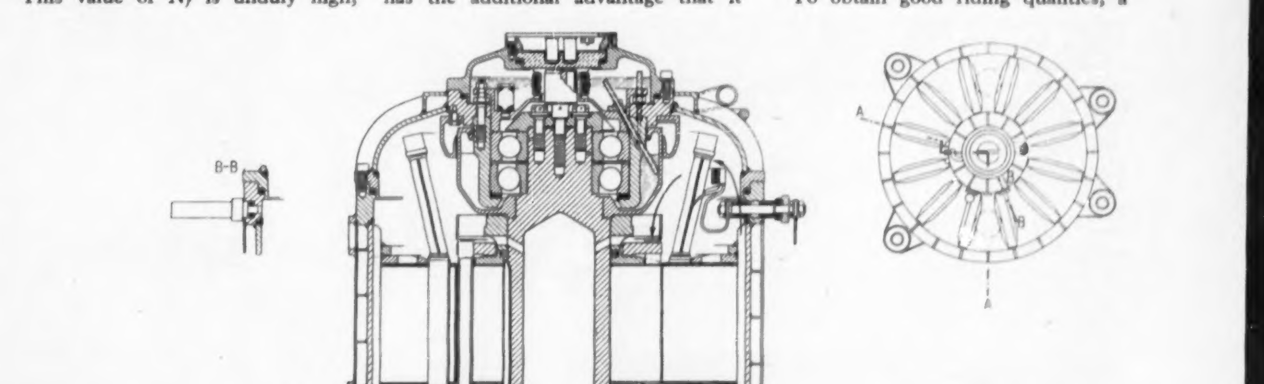


Fig. 4. The Electrogyro comprises a 1½ ton flywheel and a squirrel cage motor generator with a water-cooled stator

ratio of $a:b = 1{\cdot}8$ should be aimed at, where a and b are the distances between the centre of gravity and the front and rear axle respectively. Furthermore, it is advantageous for the wheelbase $a+b$ to be not less than 0·6 of the overall length of the vehicle, and also for $a \times b = 1{\cdot}1\, I_b/M_b$, where I_b is the moment of inertia of the sprung mass about the transverse axis through the centre of gravity, and M_b the sprung mass.

Consider, for example, a single-deck bus weighing 5·5 tons empty and 9·5 tons fully laden. Assume that it has a 5 ft diameter flywheel weighing 1,800 lb and that the polar moment of inertia I about the axis of the flywheel is 292 lb-ft-sec². Also, $a = 9{\cdot}65$ ft, $b = 5{\cdot}35$ ft and $M_b = (5{\cdot}5 - 1{\cdot}5)2{,}240/32{\cdot}2 = 278$ lb-sec²/ft for the empty vehicle, and $M_b = (9{\cdot}5 - 1{\cdot}5)2{,}240/32{\cdot}2 = 556$ lb-sec²/ft in the fully laden condition. Since $a \times b = 51{\cdot}5 = 1{\cdot}1\, I_b/M_b$, the value of I_b is 13,000 and 26,000 lb-ft/sec² for the empty and fully laden conditions respectively. To ensure an acceptable degree of comfort, the natural frequency of vertical vibrations, that is, bounce, should not exceed about 90 c/min, whilst the pitch frequency should be of similar order and generally should not exceed about 100 c/min. This can be attained, for the vehicle under consideration, by making the front springs 1·26 times stiffer than those at the rear.

If a gyroscope is acted upon by an outside force which precesses the axis of spin at a rate ω_1, then the couple at right angles to it is $I\omega\omega_1$, where, as before, I is the polar moment of inertia of the disc about its axis of spin. With a static spring deflection of about 4 in, under full load, and a dynamic deflection of 1 in at a natural frequency of 90 c/min, the angular displacement is 22 min. The resultant angular velocity ω_1 is 0·0064 rad/sec. With these values, $k^2 = 292/55{\cdot}8 = 5{\cdot}23$ ft², and $\omega = 100\pi$ at 3,000 r.p.m., so that $Mk^2\omega\omega_1 = I\omega\omega_1 = 1{,}800 \times 5{\cdot}23 \times 314 \times 0{\cdot}0064/32{\cdot}2 = 585$ lb-ft. If the distance between the springs is 3 ft, the springs on one side of the vehicle will have an additional load of about 50 lb. This load will be reduced as the speed of the flywheel decreases but will increase with the rate of pitching. If the flywheel rotates clockwise and the bus front rises, so that the axis of spin is inclined backwards, then precession will increase the load carried by the off-side springs.

Also of interest is the free oscillation of the gyroscope,[4] the frequency of which is given by:

$$f = \frac{In}{\sqrt{(I+I_b)(I+I'_b)}}\ \text{c/min},$$

where n is the flywheel speed in r.p.m., $I = Mr_o^2/4$, its moment of inertia about a diameter, and I_b the moment of inertia of the sprung mass about the longitudinal axis through the centre of gravity. With the data given previously,

$$f = \frac{292 \times 3{,}000}{\sqrt{(87+278)(87+88{\cdot}5)}} = 3{,}500 \text{ c/min}$$

for the empty condition. If the vehicle is fully laden, $f = 4{,}680$ c/min.

Thus, resonance with the suspension might be encountered with the flywheel running at 57·7 and 57·5 r.p.m. respectively, which is scarcely of interest in service. However, oscillations about a horizontal axis, and the resultant gyroscopic action, might lead to heavy bearing loads. Because of this, it is necessary to install the Electrogyro on flexible mountings in the chassis. These mountings also prevent the transmission of shock loads to the gyro when the vehicle is traversing rough terrain, and they permit a limited amount of precessional motion to take place freely.

So far as the electrical installation for this bus was concerned, it was most desirable that the vehicle should be fed from the city service, which carries three-phase current at 50 c/sec. Since it was undesirable to limit unduly the number of supply points, their cost had to be kept to a minimum.

Therefore it was decided to adopt A.C. supply throughout, thus eliminating the necessity for rectifiers and their control equipment. In addition, squirrel-cage type motors, both to drive the flywheel and for vehicle propulsion, were considered attractive because of their unsurpassed simplicity and consequently economy both in first cost and subsequent maintenance expenses. In fact, it was fully appreciated that, in certain circumstances, the employment of gyrobuses was only justified if the total installation cost was substantially lower than that of the installation necessary for trolleybuses. For this reason, the layout of the electrical components was of critical importance. In fact, considerable ingenuity, based on the great experience of these manufacturers in the field of main line railway A.C. electrification, notably in Switzerland and France, was shown in regard to the layout of the electrical components of the vehicle.

Gyrobus equipment

The final solution of the various fundamental problems already outlined has called for a considerable amount of original and highly ingenious development work for which the Swiss industry in general, and Oerlikon in particular, are justly famed. Two gyrobuses, each carrying a total of 35 seated and 35 standing passengers, have been running in regular service, since September,

Fig. 5. An Electrogyro unit for a bus

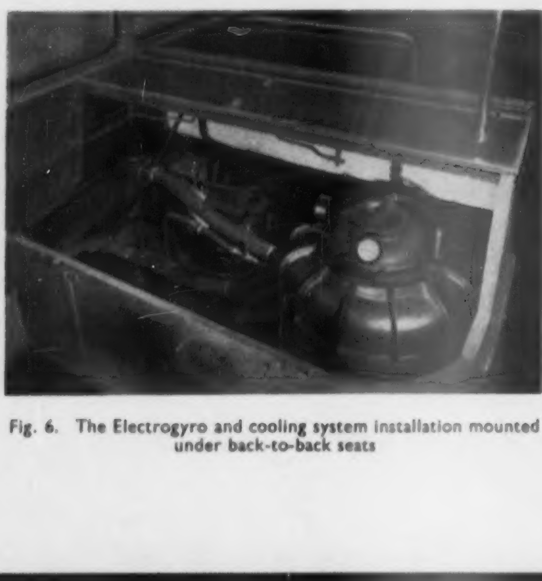


Fig. 6. The Electrogyro and cooling system installation mounted under back-to-back seats

1953, over a 2·8 mile long route at Yverdon in Switzerland. Also, twelve vehicles have been put into service recently at Leopoldville in the Belgian Congo. A further three gyrobuses, for a 4·8 mile long route from Ghent to Merelbeke, are at present in course of construction for the Société Nationale des Chemins de Fer Vicinaux.

The gyrobus for the Ghent-Merelbeke route is shown in Fig. 2. This vehicle weighs 11 ton, when ready for operation, and carries 35 seated and about 35 standing passengers. Its fully laden weight is 16·5 ton. The flywheel is 5 ft 4 in diameter and is mounted, with its axis vertical, under back-to-back seats near the centre of the vehicle. The flywheel, which weighs 1·5 ton, is forged from chromium nickel molybdenum alloy and is directly coupled to a squirrel-cage motor, Figs. 4 and 5. Both the motor and the flywheel are accommodated in a sealed housing filled with hydrogen at a pressure of about 10 lb/in² absolute. The shape of the flywheel was chosen to give maximum energy storage capacity for a given weight and maximum speed.

When running at maximum speed, the flywheel stress is only about 30 per cent of the ultimate tensile stress of the material. The ratio of the weight of the laden vehicle to that of the flywheel is about 10:1; this is considered by the makers as a generally desirable value. A 50 cycle motor-generator is directly coupled to the flywheel and its speed cannot be increased above 3,000 r.p.m. By the employment of an intermediate gearbox, the flywheel speed could be increased, but the cost and weight of such a box might offset the advantages gained.

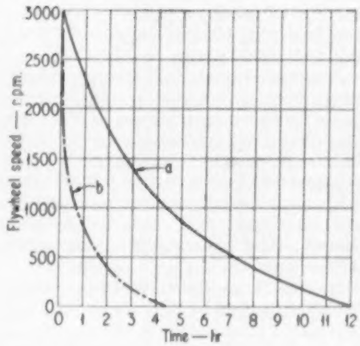


Fig. 8. Effect of windage losses on the speed of the Electrogyro

The shaft of the three-phase induction motor-generator is flanged directly to the flywheel and the complete assembly is carried by three ball bearings, one of which reacts the axial thrust. Hydrogen is circulated, in the manner indicated by the arrows in Fig. 4, by a small centrifugal impeller attached to the flywheel. The windage of the flywheel also effectively assists the circulation. To ensure efficient motor-generator rotor cooling, as well as to facilitate the circulation of hydrogen through the assembly, the squirrel-cage bars are of tubular form so that the gas can pass through them. Windage losses have been kept to a minimum by shaping the housing to follow closely the contours of the flywheel. The average value of the ratio B/D where B is the gap and D the flywheel diameter, is about 0·0175.

A water jacket is incorporated round the housing of the motor-generator. The coolant is circulated through a radiator installed in conjunction with an electrically driven fan that runs at 1,500 r.p.m. This fan and radiator assembly is mounted beneath the floor, close to the Electrogyro, Fig. 6. Two small containers in the flywheel housing carry silica gel to absorb any moisture that might have been enclosed in the unit during assembly. A vacuum gauge is mounted directly on the housing.

The complete assembly weighs about 2·9 ton and is carried on four flexible mountings on the chassis. These mountings comprise rubber blocks in which there are steel helical spring inserts. The correct proportioning and positioning of these mountings is of considerable importance so far as their reactions and consequently their life is concerned. They must be fairly flexible and should be positioned in the plane of the centre of gravity of the assembly. In earlier buses, standard vehicle components, modified to carry the Electrogyro, were employed, but in the latest vehicles the chassis has been designed specifically for this application, so the members are suitably

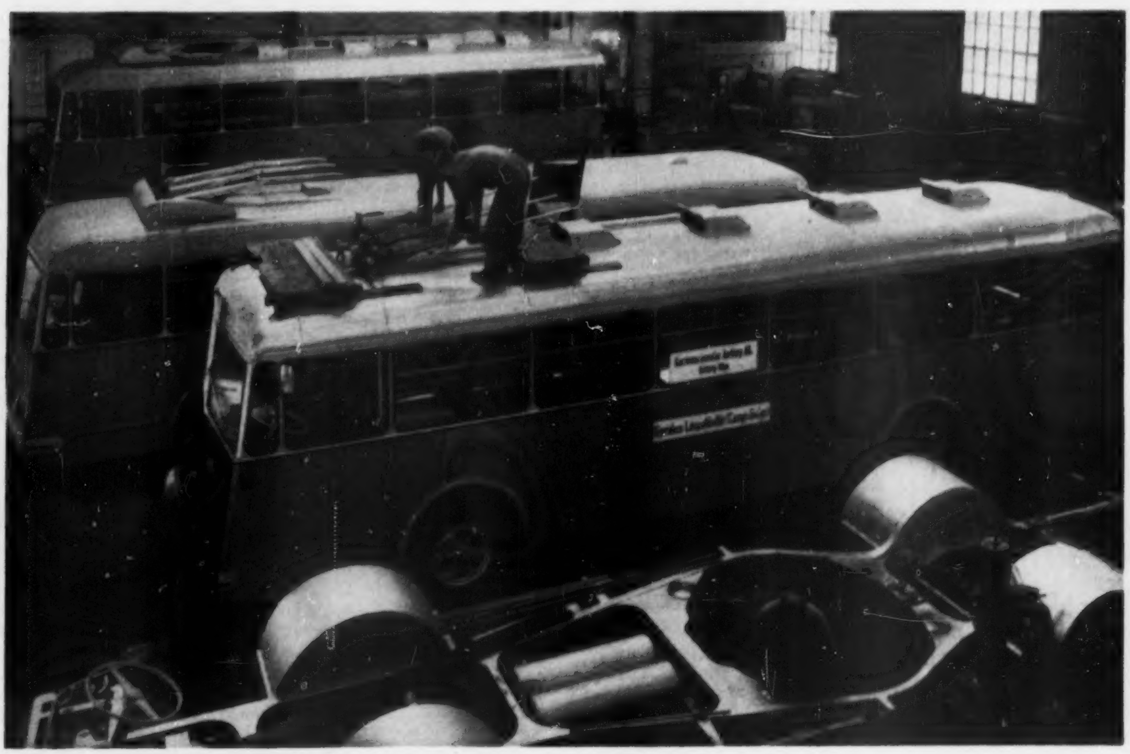


Fig. 7. Electrogyro vehicles for Leopoldville in the course of construction

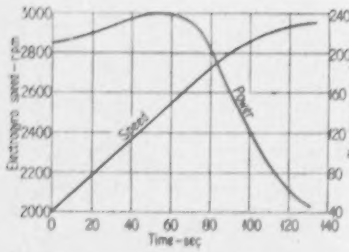


Fig. 9. Power and time required to accelerate the Electrogyro

shaped to accommodate the flywheel housing, Fig. 7.

The energy stored in the flywheel running at 3,000 r.p.m. amounts to 24×10^6 ft-lb or 9 kW-hr. Under zero load conditions, it takes about 12 hours for the wheel to slow down to standstill; the rate of loss of speed, and with it of available energy, are indicated in Fig. 8. From this it can be seen that the speed decreases more rapidly than indicated by the simplified theoretical analysis. However, in this analysis it was assumed that the flywheel was of simple disc form, so undoubtedly the more complicated shape of the actual flywheel, together with the effect of the motor-generator rotor, are responsible for higher windage losses. The actual windage and bearing losses are about 6 h.p. at 3,000 r.p.m.

Used as a motor, the motor-generator runs from a 500 volt supply, but to limit the maximum current to 350 amp, the circuit incorporates a series choke coil and parallel condensers. These improve the power factor at small slip, and improve torque and acceleration characteristics near the synchronous speed. The acceleration characteristic of the flywheel is shown in Fig. 9.

In the desirable range of operation, which is 2,000 to 2,950 r.p.m., the rate of charge is about 1 kW-hr per 20 sec, and is at an average efficiency of 70 per cent. The increase in flywheel speed is directly proportional to time up to about 2,700 r.p.m., but it takes about two minutes to increase the speed from 2,000 to 2,925 r.p.m. So far as charge time is concerned, the nominal maximum speed of 3,000 r.p.m. is in the range of diminishing returns. The circuit has been designed to ensure that the power absorption increases slightly with increasing speed, Fig. 9, before falling off again with improved power factor. This avoids undue shock loads being imposed upon the mains.

The Electrogyro can be fed from the

Fig. 10. On the right-hand side of the driver is the voltage control lever mounted on the dash

normal 220 V, three-phase supply throughout the night so that the vehicle is ready for operation in the morning. In this way, it can be kept running at about 2,900 r.p.m.; the current consumption in these circumstances is about 6·5 kW. With the same supply, it would take 25 min to accelerate the unit from zero to 2,500 r.p.m. For the final charge, the bus can be moved to the nearest main charging point.

When the induction motor is employed as a generator, its excitation current is supplied by static capacitors connected in ten steps. The flywheel speed, of course, determines the frequency and the magnetic characteristics of the generator.

A certain minimum capacitance, depending on the flywheel speed, is required to bring the circuit consisting of the generator and condensers into resonance and thus to boost the residual generator voltage, that is, to excite the generator. The voltage fed to the motor is controlled by varying the amount of capacitance connected to the circuit. This action is similar to fuel supply regulation in normal buses, and its effect is to control the torque output of the motor, Fig. 10. The voltage fed to the motor is limited to the maximum safe value by a special device. Metallized paper condensers are employed and appreciably improve the overall reliability of the scheme.

The propulsion motor consists of three units, all of the squirrel cage induction type, assembled in a common housing, Fig. 11. All the motor armatures are coupled together through 1·24:1 reduction gears. Each motor can be made to run at different speeds by a foot control that operates a switch to vary the number of poles in action. Over a wide range of speed, the power output of each motor is about 100 h.p. The driver effects motor and pole changes, during acceleration, by depressing a pedal with his right foot. He presses the pedal down once, to effect a pole change, and then again for a motor change, and so on, a total of six depressions being required to bring the vehicle up to full speed. Similarly,

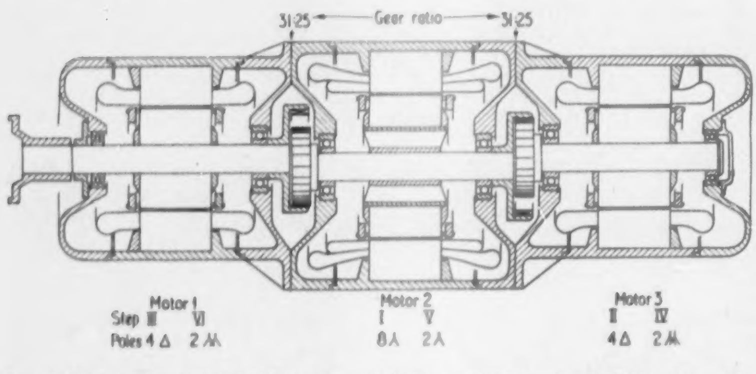


Fig. 11. The three-motor propulsion unit. With the flywheel running at 3,000 r.p.m., the output speeds in stages I to VI respectively, are: 605, 975, 1,500, 1,950, 2,420 and 3,000 r.p.m.

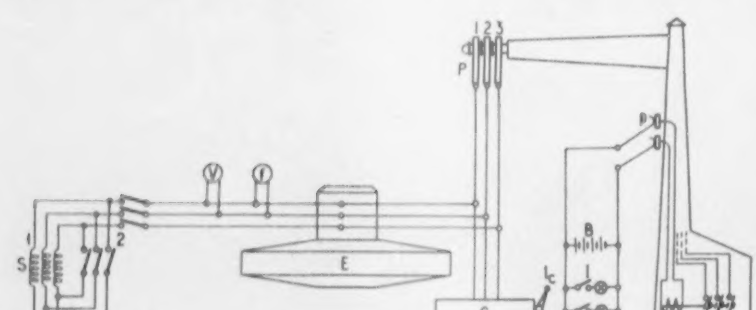


Fig. 12. Electrical circuit diagram of the Electrogyro and charging point

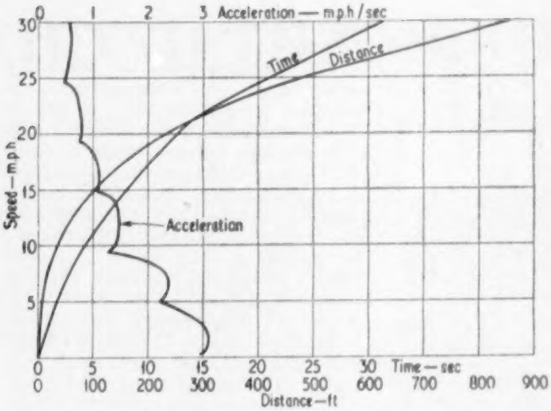


Fig. 14. Performance of a fully laden Electrogyro vehicle on level ground

when slowing down, the driver must depress a pedal on his left, again six times, before coming to a stop from top speed. The motion of the pedals is transmitted hydraulically to the control gear under the rear seats. Road speeds of recently-supplied vehicles with the motor arrangement shown in Fig. 11, are as follows:

Motor	2 poles	4 poles	8 poles
	m.p.h.	m.p.h.	m.p.h.
1	31	15·5	
2	25		6·25
3	20	10	

With the squirrel cage type of induction motor, all the losses occur within the motor, whereas with a wound rotor induction motor, using a starting resistance, most of the starting losses are external. Because of this, a small motor-driven blower to provide forced ventilation is mounted on the traction motor of the Electrogyro. The layout permits regenerative braking, the current being fed back to the Electrogyro. This not only increases the interval between charging, but also appreciably reduces brake wear.

When the left pedal is actuated to effect the regenerative braking, the vehicle drives the motor at a greater speed than the synchronous speed of the Electrogyro. This reverses the sign, or direction, of the rotor tension and current. Thus, the unit is converted into a dynamo feeding the Electrogyro. It should be stressed that regenerative braking with this type of motor is only possible so long as the motor is connected to a source at a constant voltage and frequency. Disconnecting the motor and connecting the stator to a resistance results immediately in loss of current, since the machine is not self-exciting. When the motor is overdriven relative to the generator, its brake torque is represented by curves which are, in effect, a mirror image of the torque curves, Fig. 14.

A 12 volt battery is provided for lighting as well as for the control and signal circuits. The battery is charged either by a dynamo, belt-driven from the motor output shaft, or from a dry type rectifier installed at each charging point for the Electrogyro. Compressed air for the brake system is supplied by a motor-driven reciprocating compressor, which is operated while the Electrogyro rotor is accelerated at the charging point. A cardan shaft transmits the drive from the propelling motor, which is mounted at the extreme rear. The condensers and the control gear are under the rear seats, and the compressor is under the dash, adjacent to the front door. Two compressed air vessels are mounted on the chassis frame in front of the Electrogyro, Fig. 7.

The charging point, the circuit diagram of which is shown in Fig. 12 consists of a pole with an outrigger at the top. In the pole, the choke coils L, the cut-in switch R and the battery charging rectifier are housed. The outrigger carries the feed contacts 1 to 3. When the gyrobus comes in for a charge, the overhead contacts P are lifted by an air-operated piston until they touch the dead contacts on the outrigger at the top of the pole. Then, two auxiliary contacts are swung sideways to touch a small outrigger about half way up the pole, at p. These earth the vehicle and actuate the main switch R by switching the battery feeding current through the contacts p: this cuts in the main current supply to the Electrogyro E, as well as the current for charging the battery.

The Electrogyro circuit incorporates a voltmeter V as well as a frequency meter f. Both are fitted on the instrument panel on the dash. The other components on the diagram are the voltage regulator lever l_c, the contactor c_1 and its condensers C. Originally, the lever l_c was mounted on the dash and moved in a vertical plane, but in more recently manufactured vehicles it is mounted under the steering wheel and moves in a plane parallel to that of the wheel. The voltage, and therefore the torque is increased by pulling the lever towards the driver, and *vice versa*.

Control of the triple traction motor is effected by the contactor switch C_2 actuated by the two pedals P_r and P_a and the hydraulically operated pistons and ratchet wheel r. The third pedal, P_f, applies the wheel brakes. Each charge point, even with a transformer, costs only about one-eighth of the price of one mile of trolleybus overhead gear. This, and low maintenance expenses, are the main advantages of the gyrobus, although at present the first cost of the vehicle is higher than that of a similar size of trolleybus. The overall efficiency of the vehicle, in terms of power input at the charging point to power output at the wheels, amounts to about 50 per cent.

Operating experience

Tractive effort and resistance data of the latest vehicles are plotted in Fig. 13, the tractive resistance being determined from:

$$R = W(17+0{\cdot}2V)+C_d \times 0{\cdot}26 \times A\left(\frac{V}{10}\right)^2 \text{ lb}$$

where V is velocity in m.p.h., C_d the drag coefficient, in this instance equal to 0·8, and A the frontal area, which is 73 ft². The resultant maximum acceleration is plotted in Fig. 14. It can be seen that the motor is of a size such as to ensure that when the Electrogyro is fully charged, a mean acceleration of 1 m.p.h./sec is obtainable up to a speed of 30 m.p.h. The tractive effort curves show that the torque rises as the speed increases until the peak value is reached; then it rapidly decreases with further increase of speed. This means that when the vehicle is negotiating gradients the driver has to change down more frequently than with diesel-engined vehicles, with which the torque in each gear increases as the speed decreases over a fairly large range. However, as the vehicles are mainly intended for operation over level routes, this feature is of secondary importance. In fact, since the tractive

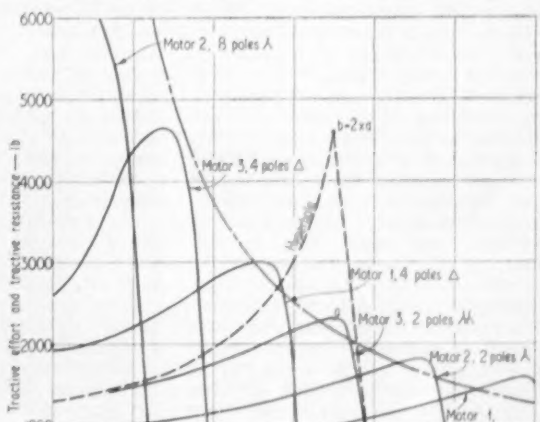


Fig. 13. Tractive effort and tractive resistance of the latest Electrogyro vehicles

effort curves are almost parallel to the curves of tractive resistance, the acceleration in each gear is almost constant.

With four 10 sec stops per mile, average speeds of up to 14 m.p.h. have been obtained, although scheduled speed, of course, depends upon traffic conditions as well as the frequency of stops along the route. In general, the scheduled speed is about 10 per cent lower than that obtained with trolley-buses. This is mainly owing to the time required for recharging. The maximum permissible intervals between recharging are determined by the fact that the energy drop between charging points should be not too great, otherwise the time required for charging is too long. Also, an unduly large reduction in flywheel speed means a drop in frequency and with it a reduction of maximum speed of the vehicle. A reduction in flywheel speed from 2,950 r.p.m., at which speed the stored energy amounts to 8·7 kW-hr, to 1,800 r.p.m., releases 5·5 kW-hr which, on a level run without stops, would enable the fully laden vehicle to travel about 5 miles.

Under actual operating conditions this amount of energy is used up after about 1·5 miles. The general relationship between the mileage done by a fully laden vehicle, using 75 per cent of the stored energy and slowing the flywheel down to half of its maximum speed is plotted in Fig. 15. The distance between stops is assumed to be 1,000 ft and the maximum speed 25 m.p.h. From these curves it can be seen that this type of vehicle is most suitable for runs on the level, with infrequent stops and in relatively light traffic. The weight of the vehicle should be kept to a minimum unless it is practicable to recharge more frequently.

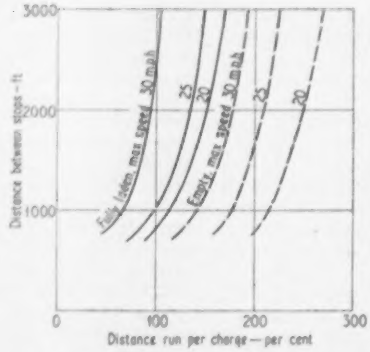


Fig. 15. Effect of maximum speed, weight and distance between stops on mileage between charging points

Since a period of about 20 sec is required to accelerate the flywheel to increase by 1 kW-hr the amount of energy stored, about 2 min will be required to accelerate it from 2,000 to 2,950 r.p.m. This is well within the capacity of the terminals. In practice, the distance between charging points is determined by the time available for charging. If 40 sec is accepted as a reasonable period, the charging points must be spaced at intervals of 0·75 to 1·25 miles.

The Yverdon route is about 2·8 miles long. A charging point is provided at each terminus as well as at an intermediate station on the route. The distance between stops is about 0·25 miles and the current consumption is 3·5 kW-hr/mile. In Leopoldville the distance between stops is between 0·44 and 0·69 miles, and the charging points are spaced at intervals of 1 to 1·25 miles. When the distance between stops was changed to one every 0·625 miles, the consumption was reduced to 2·5 kW-hr/mile. The Ghent route is 5·3 miles long with stops every 0·31 miles. A scheduled speed of 13 m.p.h. is maintained and the estimated current consumption is 3·5 kW-hr/mile.

References

1. *Engineering*, 19th October, 1945.
2. LANCHESTER; British Patent, 7949/1950.
3. PFLEIDERER; "Die Kreiselpumpen," *J. Springer*, Berlin, 1949.
4. C. INGLIS; "Applied Mechanics for Engineers," *Cambridge University Press*, 1951.
5. B. STORSAND; "Der Elektrogyro, ein Kinetischer Energiespeicher für Fahzeugbetrieb," *Schweiz Bauzeitung*, No. 15, 1951.
   C. CARRARD; "Le Gyrobus et le Gyrotracteur," *Genie Civil*, 1st January, 1952.
   E. GILLON; "Le Gyrobus," *Bulletin de la Société Belge des Electriciens*, Vol. 71, No. 1, 1955.
   E. DUNNER; "The Gyrobus," Special Course of Lectures on Electric Traction, Borough Polytechnic, 1955.

SAFER CHROMIUM PLATING

THE chromium plating process is usually associated with certain hazards. Thus, the baths used contain rather concentrated solutions of chromic acid as well as small percentages of other chemicals. High cathode current densities are required, and a large volume of hydrogen is liberated during plating, while oxygen is evolved at the anodes. These gases are produced in the form of multitudinous bubbles, which burst violently at the surface of the concentrated acid solution, throwing out a fine mist of droplets which may be carried a considerable distance. This mist is both corrosive and toxic, and it may adversely affect other plating processes, as well as causing damage to neighbouring buildings and their contents.

In general, an exhaust ventilation system is necessary continuously to remove the mist as it is formed, and the quantity of air exhausted for this purpose can be quite large. For example, to carry away the mist formed in a 2,000 gallon tank installation an exhaust rate of as much as 10,000 ft^3/min may be required, with consequent heavy costs both in capital installation and in the power consumption of the electric motors. Furthermore, even with the most efficient ventilating systems it is not always possible completely to obviate the mist formation, particularly with wide tanks and where there are strong draughts. There is also always a strong corrosion problem in the ducts of the ventilating system, which become coated with condensed corrosive salts. Furthermore, since the loss of chromic acid through mist and spray can amount to as much as 30 per cent of the total acid used, a considerable additional expense is involved, as well as a health hazard.

For all these reasons it is particularly interesting to learn that a new surface-active fluorinated hydro-carbon agent called Zeromist, which is now available, has the property of creating a thin, safe foam blanket during operation which completely stops the evolution of chromium spray. The product comes in the form of tablets and its use is said to save up to 70 per cent of the chromic acid and greatly reduce the carry forward of chromium solution on the racks as well as almost completely eliminating the toxic and harmful chromium spray. It is not affected by the anode and cathode current densities normally used in decorative chromium plating (for deposits up to 0·001 in). The initial quantity needed varies according to the operating temperature of the solution and lies between 1½ lb and 3 lb for each 100 gallons of chromium solution. Because of its extreme stability and the fact that it is lost from chromium plating solutions solely as a result of drag-out, the rate of consumption of Zeromist once the initial addition has been made is remarkably low. It is, therefore, economical in use.

The availability of Zeromist, from the Electro-Chemical Engineering Co. Ltd., of Weybridge, Surrey, is a very important step forward from the point of view of health and safety control for factory staffs in localities where chromium plating is going on. It is to be hoped that it will be widely used as it provides such an excellent means of eliminating what has been both an expensive and dangerous hazard of the standard chromium plating process in the past.

Furthermore, important savings will be possible in both capital and operating charges involved in the installation of a ventilation system which, while still as yet required by the Factory Act, can clearly now be of smaller capacity. There will also be a saving of fuel since there will not be the same loss of heated air, and expensive scrubbing apparatus can also be eliminated.

ROAD TRANSPORT FOR RAILWAYS

Some of the Latest Developments of the German State Railways

ON the Continent, and indeed in many other parts of the world, where there are good, long-distance trunk roads, the competition beween railways and road transport is keen. This is a good feature not only from the point of view of the economies of these countries, but also in that it is a stimulant to progress in both the road transport and railway industries. It would appear that long-distance transport of loads of high density, such as iron ore or coal, will remain for at least many years to come in the hands of the railway undertakings. However, the shorter the run, the higher is the proportion of the total transit time that is wasted in transferring the load from the railway to the road vehicle. Also, there is a danger of damage to the goods during the transfer. The railways have directed considerable effort towards overcoming these problems, although even when the solution is found, there still will remain the difficulty of cutting down the time wasted and the liability to damage in shunting and making up trains.

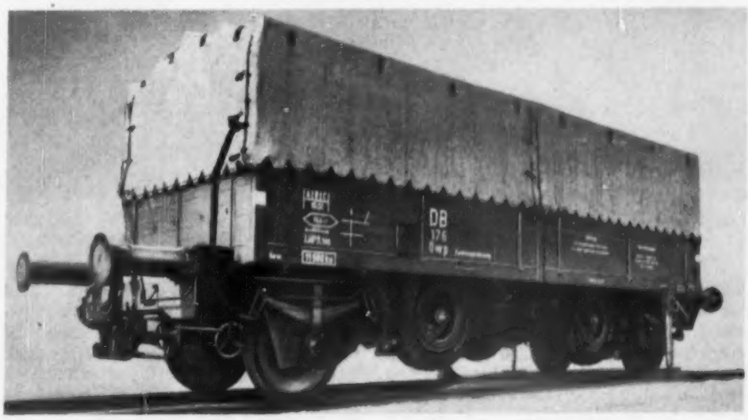


Fig. 2. This wagon has a retractable road-wheel undercarriage, and the railway bogies and buffers can be removed. In this illustration, only the rearmost pair of jacks, for lifting the vehicle to change from railway to road wheels, is fitted to the vehicle

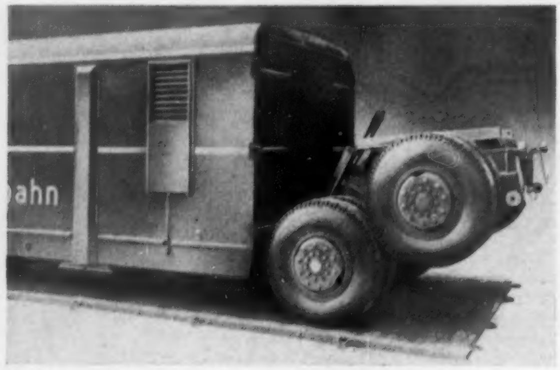
The German State Railways have made a number of different approaches to the problem of saving time in delivering goods from the railway to the ultimate destination. The simplest solution of all is to modify a more or less conventional railway wagon so that it can run on the road. This is done by bolting pneumatic tyred road wheels to the outer faces of the four wheels of the railway wagon, Fig. 1. On this vehicle, the road wheels, which are equipped with Continental, 12·00-22 HD Super tyres, can be fitted in as little as ten minutes. The truck carries 9 metric tonnes and weighs 7·2 tonnes empty. At the front, it has one turntable bogie with a single pair of wheels, and at the rear there is a fixed bogie, also with a single axle. The road wheels, of course, are of larger diameter than the railway wheels and are bolted on while the truck is on the railway lines. A conventional drawbar frame is fitted so that a tractor can be hitched to the truck to tow it off the end of the lines on to the road and to its final destination. When the road wheels are not in use, they can be stowed on racks underneath the wagon; alternatively, spare wheels can be kept in railway depots.

This arrangement has the advantage that the load remains in the wagon throughout the whole of the journey, so there is neither waste of time nor any possibility of damage due to handling between the railway and road vehicles. The disadvantage is that, to meet the legal requirements with regard to buffer loads, the vehicle must be very robust and therefore relatively heavy. Moreover, so far as road transport is concerned, the buffers, railway axles and wheels represent so much dead-weight.

Fig. 1. In this illustration, one pair of road wheels is shown bolted to the railway wheels and the other pair is stowed in the rack just in front of the rear wheel bogie

Another type of vehicle has been developed by the German State Railways to overcome the disadvantage of having to carry the railway undercarriage and buffers on the vehicle when it is travelling on the road. It has a retractable road-wheel undercarriage and removable railway bogies. The buffer assemblies are also mounted on the railway bogies, so they are not carried on the truck when it is on the road. This vehicle weighs 22·4 tonnes when laden for rail transport, and carries a 10½ tonne load.. Metz 11·00-20 eHD Super tyre equipment is used. Single-axle bogies are employed both for the road and the railway wheels.

To transfer the vehicle from the railway to the road, four hand-operated hydraulic jacks are fitted, two at each end, Fig. 2, and extended to take the weight of the truck. Then, two small diameter flanged wheels at each end, mounted on legs that are swung inwards to retract the wheels, are lowered until the legs are vertical and the wheels on the rails. These prevent the buffer and bogie assemblies from pivoting about the axles and falling outwards as the vehicle is lifted clear of them. When the vehicle has been lifted, the railway bogies are wheeled



Left: The Henschel 145 TS tractor used to tow the semi-trailer, which has a removable rear bogie. Right: where the space behind the vehicle is limited, the rear bogie can be folded to facilitate removal or stowage

away. Then the road wheel undercarriage is lowered and locked. Next, the hydraulic pressure in the jacks is released, the vehicle lowered until the road wheels take the weight, and the jacks are stowed in their racks. Finally, a drawbar is attached to either end to tow the vehicle away. The road-wheel bogies are turntable-mounted and either one can be locked, according to which end the drawbar is fitted. This arrangement has the disadvantage that the vehicle still has to be strong enough to react the compressive loads from the buffers.

All the disadvantages so far mentioned can be obviated simply by loading a road vehicle on to a railway wagon. However, it is necessary to have suitable loading quays or ramps so that the vehicle can be driven on, otherwise time is wasted in slinging the vehicle with a crane. For driving directly on to the railway wagon, semi-trailers are best, particularly for loading on from the side of the railway truck, since they are more manœuvrable than lorries. Moreover, the tractor does not have to be transported with the load, and this represents a saving in capital equipment. The main disadvantage of this method of transport is that either expensive low-loading platform-wagons must be employed or the height of the road vehicle must be severely restricted.

To overcome these difficulties, a semi-trailer with a removable rear road-wheel bogie has been designed. The semi-trailer is manufactured by E. H. V. Lienen G.m.b.H., of Bochum, and the tractor is a Henschel 145 TS unit, Fig. 3. In the laden condition, the vehicle weighs $25\frac{1}{2}$ tonnes and in the unladen condition it weighs 9 tonnes. When the vehicle has been driven on to the railway wagon, four hydraulic jacks, built into the sides of the trailer, are extended to support the body—the hydraulic power is furnished by the engine-driven pump on the tractor. Next, the tractor is driven clear and the bogie withdrawn to the rear. For economy in space, the bogie frame can be folded as shown in Fig. 3. To facilitate manœuvring the bogie as it is withdrawn, both axles can be steered hydraulically.

Mounted on swinging links on the rear end of the bogie is a cross shaft, on each end of which is a bobbin. Before the bogie is removed from under the trailer, this shaft is swung down and locked with the bobbins firmly in contact with the rear wheels. A worm wheel on the centre of the cross shaft meshes with another on the end of a crank handle, which is turned manually to drive the wheels to take the bogie away. Since the worm drive is irreversible, it is impossible for the bogie to get out of hand on an incline. After the bogie and tractor have been removed, the jacks are retracted to lower the body on to the platform of the railway wagon. The bogie has eight wheels and two axles, and is equipped with Veith B.F. Goodrich 11·00-20 cHD tyres.

The principle of loading containers from road vehicles on to railway trucks and vice versa has been applied in most parts of the world for many years. However, it is not without its disadvantages: cranes and slings must be available for effecting the transfer; moreover, loading and unloading from the road vehicle may take a long time. To overcome these disadvantages, the German State Railways have introduced a special semi-trailer vehicle for containers, Fig. 4. The semi-trailer is equipped so that the container can be

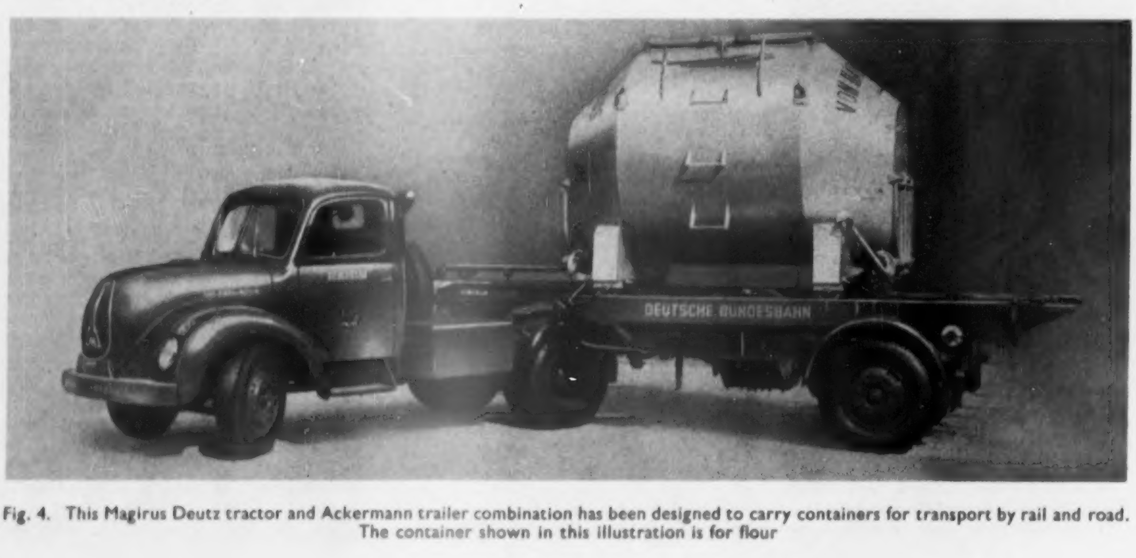


Fig. 4. This Magirus Deutz tractor and Ackermann trailer combination has been designed to carry containers for transport by rail and road. The container shown in this illustration is for flour

transferred without a crane either to the ground or to a railway wagon. For certain applications, the contents of the container can be unloaded from the road vehicle by side or end tipping, and the containers can be designed so that they can be filled by means of hoppers.

A Magirus Deutz tractor is used and the semi-trailer is an Ackermann unit, designed to carry a 5 tonne container. At the rear end of the semi-trailer is a four-wheel bogie. The wheels are mounted in pairs on the ends of two short axles installed one on each side, with their axes in line. Each axle is mounted at its centre on a semi-elliptic spring, which thus is between the wheels. Continental 8·25-20 eHD tyres are employed.

The container is equipped with four small wheels, which rest in channel section runners on the semi-trailer. The frame that carries the runners can be tipped to either side or to the rear. Also, it can be raised about 10 in by a hydraulic jack, and tipping can be effected from the elevated as well as the normal position. This feature is incorporated so that the runners can be raised to a level higher than the railway truck platform on to which the container has to be loaded. Thus, the container does not have to be lifted or hauled on to the railway truck. For side tipping, the runners are turned through 90 deg in a horizontal plane, so tipping is always effected over the rear end of the runners.

A hydraulic jack is mounted in a channel between the runners to draw the container on to or let it down off them. The connection between the hydraulic jack and the container is of interest. Parallel to the ram and attached to it is a longitudinal frame. This frame carries two sprockets, one at each end, with their axes horizontal and at right angles to the frame. An endless chain is assembled over the sprockets, and the whole assembly is housed, together with the jack, in the channel. The lower strand of the chain is anchored to the base of the channel and the upper strand carries the connecting link to the container. Thus, the distance travelled by the container is twice the movement of the ram. This enables a relatively short jack to be employed.

CAST IRON SWARF REMOVAL

Methods Employed by Chrysler Corporation

THE problem of removing and the disposal of cast iron swarf, heavily contaminated with cutting oil, from the workheads of high-speed repetition machines at one of the Detroit plants of the Chrysler Corporation has been successfully solved by the use of Spiratube flexible ducting. A group of 26 lathes in this factory is permanently engaged, 16 hours per day, in machining brake drums for motor vehicles. Carbide tools are used on the cast iron stock, which has a Brinell hardness in the range 160-223. Approximately 8½ oz of metal is removed from each drum, and the disposal system has to convey and collect more than one ton of highly abrasive swarf every day.

The chips are removed through large-bore tubes by vacuum of the order of 6 in water gauge induced by a 40 b.h.p. electric fan. They are conveyed to a cyclone-type collector, where they are baffled to reduce their velocity before being allowed to fall into a water bath at the collector base.

Originally the main removal trunks of 12 in internal diameter were made entirely of sheet metal tubing. It was found, however, that even with tube of ⅛ in wall thickness, a tube life of only about two months could be expected at the bends where directional changes of the air/chip mixture took place. Owing to the abrasive nature and high velocity of the chips heavy erosion occurred at these bends.

Lengths of Spiratube flexible ducting, having a Neoprene impregnated wall presenting an unbroken Neoprene surface to the bore, were substituted for the rigid metal at the critical bend positions. It was found that this material was practically abrasion-proof, and after two years service there was no appreciable deterioration of the flexible sections.

Ducting of various diameters, ranging from 4½ in I.D. at the workheads of the individual lathes to 12 in I.D. at the main chip ducts, is used. Removable annular sheet metal shrouds surround the brake drum at the work position. The 4½ in. Spiratube is connected to the chip take-off point near the rim of each shroud, and has its bore axis disposed at a tangent to the periphery of the brake drum. The chips are evacuated from the work face, conducted through vertical risers into the overhead main ducts and thence to the collector. Thus the system occupies no floor space at all in the machine shop proper; the actual collector is sited away from the production area.

Spiratube is now available in the United Kingdom. It is being manufactured by Flexible Ducting Ltd., Maryhill, Glasgow. The ducting consists of a pre-formed, pre-pitched continuous spring wire helix secured between overlapping plies of a variety of multi-coated fabrics. Full details are given in a booklet issued by the Company.

Spiratube has a stable cross-section under all operating conditions and will tolerate 90 deg bends of radius equal to the duct diameter without bore diminution. It also possesses good gas flow characteristics in conjunction with extreme lightness and flexibility. As is generally known, Neoprene is highly resistant to attack from cutting and other oils, while owing to the helical-wound spring wire immured in the tube, Spiratube will withstand sub-atmospheric pressures without any sacrifice of the properties that allow it to be easily cut and joined by simple clamps to sections of rigid tubing to give long life under severe conditions.

LOW-VISCOSITY LUBRICANTS

THE benefits to be derived by reducing the viscosity of the lubricant in a compression ignition engine have been investigated by the Motor Industry Research Association under a wide range of loads, speeds, viscosities and temperatures. In the report of the Department of Scientific and Industrial Research summarizing this study, it is stated that fuel consumption can be reduced by using an oil of lower viscosity, by raising the temperature at which the oil is supplied to the bearings, or by a combination of both methods.

By the use of 5W grade oil (the thinnest crankcase oil in the S.A.E. classification) instead of the S.A.E.30 grade, the fuel consumption was improved by about 4 per cent at full throttle, rising to about 9 per cent at quarter throttle. Replacing S.A.E.30 oil by S.A.E.10W gave improvement of 2 per cent and 6 per cent at full and quarter throttle respectively.

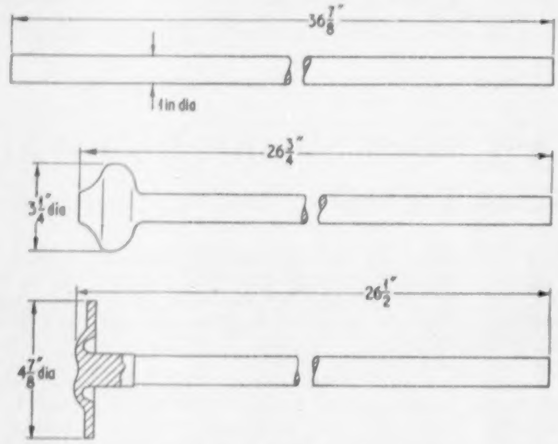
An increase of 25 deg C in oil delivery temperature can reduce fuel consumption by 3 to 4 per cent on variable throttle running. This saving is dependent upon load and falls to 2 per cent at full load.

AXLE SHAFT MANUFACTURE

An Electric Upsetting and Press Forging Production Unit

AXLE shafts are forged at the rate of 140 per hour in a compact production aggregate at the Newton Works of Garringtons Ltd., Bromsgrove, Worcestershire. The equipment comprises two Hasenclever HG80/12 semi-automatic electric upsetting machines, a Hasenclever friction screw press nominally rated at 800 tons, but capable of exerting a maximum pressure of 1,500 tons, and a 100-ton Wilkins and Mitchell trimming press. Handling the alloy steels specified for the axle shafts, the upsetting machines are virtually working at full capacity but the press is well in excess of requirements as regards both loading and speed of operation. It is capable of delivering blows at the rate of 18 strokes per minute. Similarly, the trimming press is but lightly operated. Three operators only are required, one serving the two upsetting machines alternately.

Two axle shafts are produced, having identical flanges and varying only in length. Both are formed from 1·0 in diameter bar, centreless ground to size and purchased in that condition. The stock bars are cut singly to working length on high speed cold saws. This is a batching operation and is not co-ordinated with the forging cycle. Three alloy steels are used; manganese-molybdenum steel to En17 specification and the lower nickel, chrome-molybdenum steels to specifications En110 and En111.



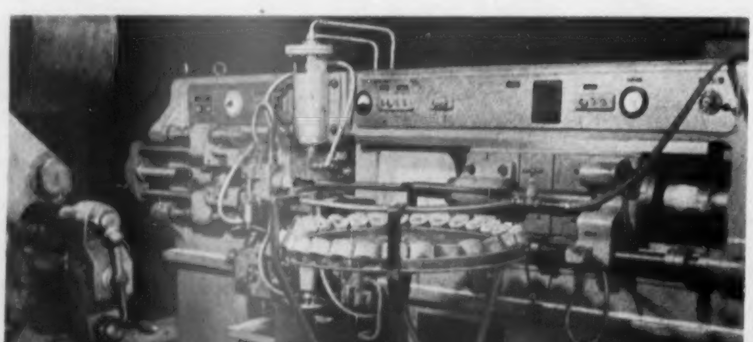
Development of axle shaft from ground bar

Cut bars are stacked on a stillage within convenient reach of the operator of the upsetting machines. Stainless steel cups are provided to receive the end of the bar to be upset. These are cut to length from black bar, recessed on one face to a cupped shape, and used in the unhardened, as received, condition. For the two upsetting machines 30 cups are held in circulation. Taken at an elevated temperature from the machine at the end of a work cycle, each cup is placed in turn on a revolvable table over which a cooling jet of air is directed continuously. This fixture may be seen in the illustration of one of the upsetting machines.

Apart from loading and unloading the operating cycle is fully automatic on the actuation of a pedal switch. Having a transformer capacity of 80 kVA, these machines bring the work rapidly up to the required forging temperature of 1,150-1,200 degC, and the oil-hydraulic ram can exert an upsetting pressure of up to 12 tons. They can handle bar stock from a minimum of $\frac{5}{16}$ in diameter to a maximum, for alloy steel bars, of $1\frac{1}{2}$ in diameter. In normal operations they can be used to upset to 10 diameters of the bar stock, but this ratio may be materially increased if necessary. For the axle shafts in the present application, 10 in of bar length are lost to produce a use having a bulbous end of $3\frac{1}{4}$ in diameter, as shown in the development drawing. Cycle time is 47-50 seconds.

The operator places a cooled cup on the end of the bar stock to be upset and positions the bar in the lower half of the clamping electrode with the back face of the cup held against the receding anvil. Upper and lower elements of the clamp and the anvil are all water cooled. The electrodes are of the type having three intersecting diametral bores in the same plane. As one bore becomes worn by use, a rapid adjustment is made to bring another bore into alignment and thus the working life of the electrodes between withdrawals for maintenance is triplicated.

On closure of the pedal switch the sequence of operations is fully automatic. The electrodes clamp the bar, the pusher ram moves up to contact the remote end of the bar and hold the other end into the cup, and the current is switched on. By the related location of the various parts about 1 in only of the bar beyond the electrodes is unsupported. Under the pressure of the ram on the bar, the anvil recedes a short distance (slightly more than $\frac{1}{4}$ in) and continued movement of the ram upsets the heated end of the bar into the cup. At the limit length of the upset bar an isolating switch on the ram feed mechanism stops the movement and reverses it, and meanwhile the upper half of the electrode is retracted and the anvil is returned to position. The machine is then unloaded, the operator discharging the use down a gravity chute to the press pit and returning the cup to the cooling

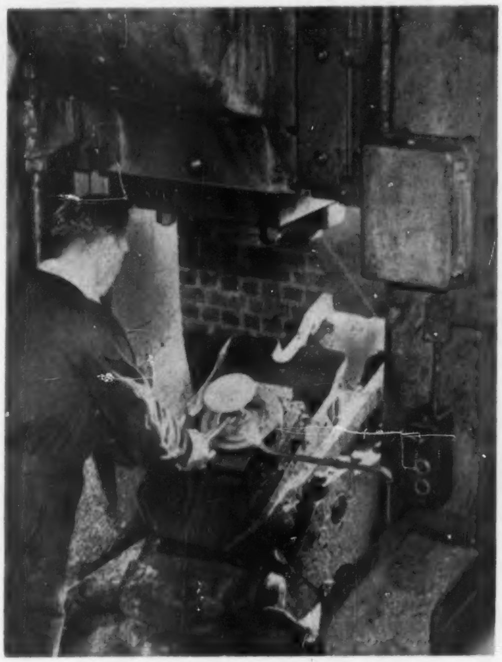


One of two Hasenclever electric upsetting machines arranged for semi-automatic operation

table, and immediately reloaded with another bar and a cooled cup.

Installed in a pit 6 ft 7 in deep, with the working platform 4 ft 0 in below the shop floor level, the friction screw press is driven by multi-belts from a 50 h.p. motor. In the usual manner the driving disc is moved inwardly towards the press axis to bring its inner face into frictional contact with the periphery of the flywheel. Rotation of the flywheel effects a downward movement of the press head, carrying the top die, by means of the vertical screw shaft. Control of the force exerted is effected by varying the period during which the driving disc is held in contact. Obviously, the longer this contact is maintained the more energy is stored in the flywheel and the greater the force of the blow as the dies are closed. An adjustable cam control device enables the driving contact to be broken at any predetermined position in the stroke of the press so that some part only of the downward movement is power driven and the remaining movement to the closure is by the momentum of the flywheel and by gravity. A pre-measured blow considerably less than the nominal rated 800 tons is used for forging the axle shafts.

The most novel feature of the press is the tilting bolster, specially designed for this application to facilitate loading and unloading and also to permit the use of a short press stroke with consequent speedier operation. A trunnion-mounted upper part, carrying the bottom die holder, is supported on an arcuate seating in the base part secured to the press bed. Both parts are bored axially to admit the plain stem of the axle shaft. By means of a compressed air cylinder, mounted vertically at the rear of the bolster and operating in timed relation to the motion of the press head, the upper part is canted forwardly for unloading and reloading and then returned to the vertical for the forging operation.

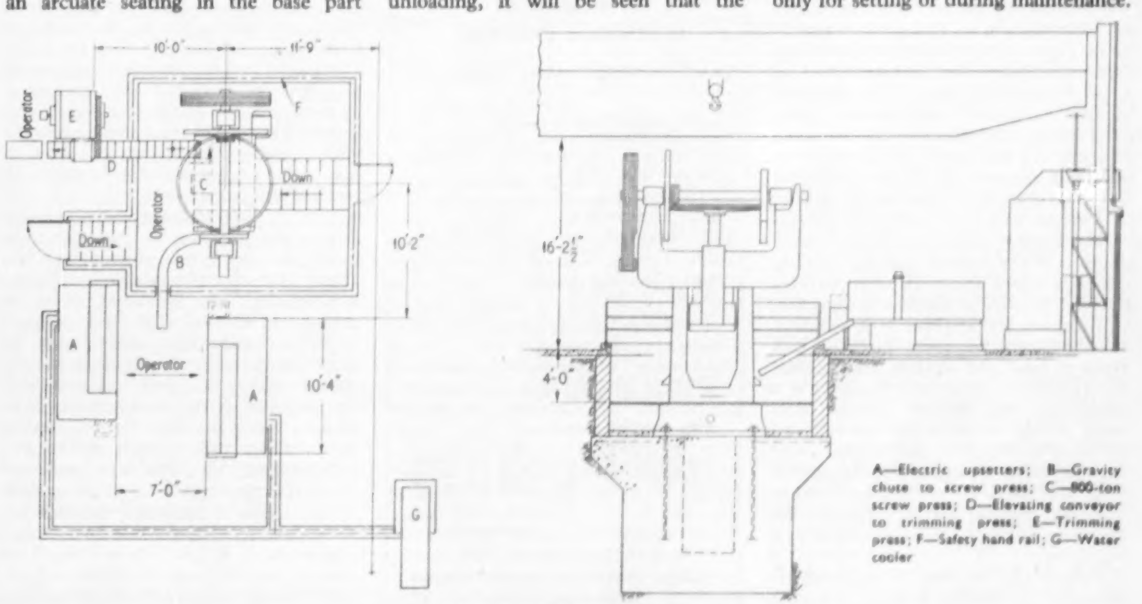


Tilting bolster on Hasenclever friction screw press

From the illustration of the bolster, showing a forged shaft ready for unloading, it will be seen that the flanged end of the shaft is lifted well above the die to a position where it can readily be gripped at the neck by tongs for withdrawal. Actually, the lower end of the shaft is supported on the arcuate seating of the bolster base.

The use received from the upsetting machine is inserted through the die to assume a similar position. On the operation of the press, the bolster is restored to the vertical position by the air cylinder and the use drops through the bore in the bolster base until the preformed head rests on the die. The bolster is held vertical against a stop, the dies register, and the forging operation is completed on the closure. An ejector plunger, rigidly connected to the press head by adjustable tie rods and sliding in the bore in the bolster base determines the finished length of the forged shaft. As the press head is raised on the return, the ejector plunger lifts the shaft until the end is above the arcuate seating and then the upper part of the bolster is tipped forward with the shaft supported on the seating. The lower face of the upper part is suitably grooved to clear the end of the ejector plunger.

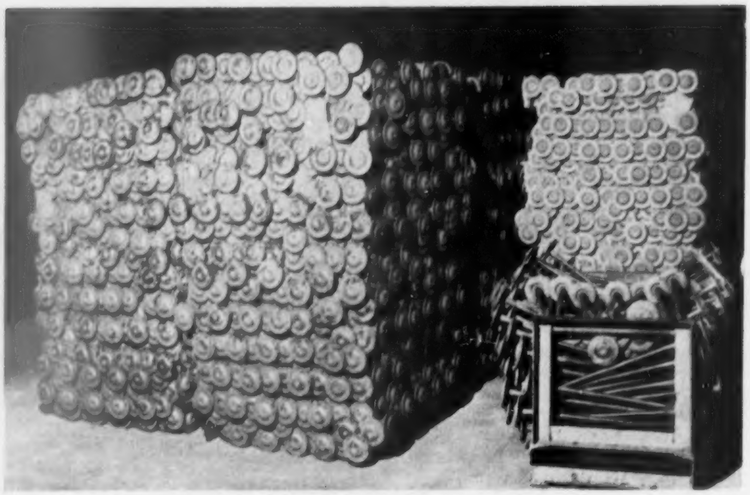
Dies of nickel-chrome-molybdenum steel are of the inserted type and mounted in holders for easy replacement. A graphite die lubricant is used and a set of dies is good for approximately 4,000 forgings before requiring routine servicing or eventual replacement. Operation of the press is by a pedal switch; the push-button control visible in the illustration is used only for setting or during maintenance.



Layout of production unit

After forging, the shaft is taken by an elevating chain conveyor to the shop floor and delivered to a stand alongside the trimming press for the removal of flash from the rim of the flange. As with the screw press, the tooling is specially designed to facilitate the handling of a long, slender workpiece. In this instance the shaft is located horizontally. It is laid in the lower part of an unsymmetrically divided die with the flange on the far side of the cutter ring. On the working stroke of the press the head lowers and spring-loads the upper part to clamp the die and complete the cutting circle. With continued movement of the head, kicker blocks drive forward horizontally the spring-retracted punch that forces the flange through the cutter ring to shear off the peripheral flash.

On the return stroke of the press, and the consequent retraction of the punch, the flash ring falls between the die and the punch into a pit ready for collection and salvage. Cutter ring elements are individually withdrawable and thus replacement can be made with the minimum loss of time without dismantling the set-up.



Finished axle shaft forgings stacked ready for dispatch

After trimming, the shafts are stacked on the shop floor to cool, inspected, and immediately dispatched. The forgings are very clean, with a light shell-scale only. Resistance heating of the bar stock is very rapid and there is no significant spread of heat along the shaft. Scaling is confined solely to the forged head portion and consequently no allowance need be provided on the diameter of the shaft and no machining of the main shaft portion is necessary.

MACHINE ATTACHMENTS

Developments for B.S.A. Acme-Gridley Automatics

TO increase the scope of work that can be produced on B.S.A. Acme-Gridley multi-spindle automatic machines, a range of special attachments is now available. By their use the need for costly secondary operations can often be eliminated and production times and manufacturing costs reduced.

For heavy recess forming cuts there are two styles of recessing attachment-swing type. One is a positive relieving type which stops the forward travel at a predetermined point. A self-contained camming mechanism then controls the movement of the tool into, and out of, the cut. As this type is operated entirely from the end tool slide, its adaptability is limited by the lead of the tool slide cams.

A pick-up attachment has been developed for chamfering or drilling the back end of the work after parting-off. It can also be used for supporting and driving the workpiece to secure a smooth cut-off free from burr. Various types of magazine loading attachments are available. For example, there is a chute type that mounts on the cross slide, with a work loader on the end of the tool slide for feeding parts into the spindle nose against an adjustable stop and ejector mechanism. Other magazine loaders can be arranged for inserting the parts through the rear of the spindle.

The form turning attachment is intended for relatively long cuts such as on shaft work for turning up to, or behind, shoulders where the cut is inaccessible by regular tooling. In operation the tool bit holder, mounted on the cross slide, carries the tool into the work to the required depth; a pusher bracket, mounted on the end tool slide, then advances the tool laterally for the required length of the form turn.

There are two oil grooving attachments, one for external and one for internal grooves. The external attachment will produce left- or right-hand spiral grooves on plain shafts. Depending upon the cams fitted, any length of groove up to 2 in can be obtained. It is possible to groove up to a recess or a shoulder. The internal attachment is primarily intended for machining internal grooves of the two-directional type. When used on a machine fitted with spindle stopping mechanism, it may also be used for machining straight oil grooves.

Two developments that can greatly reduce the need for second operation work are the cross milling and the cross drilling attachment. These, incidentally, can be used only on machines fitted with the spindle stopping mechanism, which can be arranged to stop the spindle at any station except the first and the sixth. In addition to the attachments mentioned, there are also thread cutting, saw slotting, multi-spindle drilling and independent side slide attachments.

As the application of these attachments is special for each individual job, it is desirable to consult the tooling engineers of B.S.A. Tools Ltd., Kitts Green, Birmingham, for advice regarding setting up and adaptation of the machine to give the maximum benefit.

GAUGING THIN FILMS

The Measurement of Metallic or Non-Metallic Coatings on Metal Bases

INSTRUMENTS to measure unilaterally the thickness of metal plating or non-metallic layers on metal are of considerable interest to the automobile industry. They can be used to determine non-destructively the depth of priming and lacquer coatings on vehicle bodywork, the thickness of nickel or chromium plating on exposed metal parts, the thickness of metal layers or flashings of bearings and the thickness of hard chrome plating on such items as piston rings and cylinder or liner bores. The magnetic principle of these instruments, which are handled in Great Britain by Solus-Schall Ltd., 15-18 Clipstone Street, Great Portland Street, London, W.1, is also employed for the precision gauging of steel sheets to check for uniformity of thickness prior to pressing.

Three physical methods are fundamental to these instruments. First, the attraction between a magnetic pole and a sheet of ferromagnetic material is a measure of the distance between them and, therefore, of the thickness of the non-magnetic coating.

Secondly, by inducing eddy currents in a metallic base and measuring their reaction on a test coil placed on the work, the distance between that coil and the metal, that is, the thickness of the intervening non-metallic layer, can be ascertained.

Thirdly, a magnetic yoke with primary and secondary windings is placed on a coated steel sheet and the magnetic field which is induced in that sheet by means of the primary coil is allowed to induce a voltage in the secondary winding. That voltage is a measure of the magnetization which has taken place and is influenced by the distance between the yoke and the steel sheet as determined by the thickness of the non-magnetic coating on the steel.

The fourth instrument, for the unilateral measurement of sheet thickness, is somewhat similar to that referred to in the previous paragraph. In this, however, the yoke consists of a permanent magnet in which the field is not electro-magnetically produced. The thickness of the metal sheet determines the total flux that can pass between the poles of the yoke when the sheet acts as keeper. Thereby, the demagnetization effect of free poles is reduced and the degree of demagnetization is a measure of the thickness of the sheet.

Plating thickness pull-off gauge

This instrument serves for the measurement of non-magnetic layers of any thickness up to 0·5 mm. on a magnetic base. In particular, it is suitable for the measurement of the thickness of:

(a) Copper, zinc, chromium, paint, lacquer or enamel coatings on iron;
(b) Foils made of paper, plastics or non-magnetic metals;
(c) Non-magnetic plating on iron.

It may also be used for discriminating between steels in the transformation range between austenite and the ferromagnetic state.

Pull-off gauge for plating and paint layers on iron or steel

Its principle of operation is the measurement of the adhesion of a small permanent magnet terminating in a sphere of high permeability material. The sphere is mounted on the end of a ratchet-profiled plunger slidable in a cylindrical casing and normally retracted by a helical spring. Each ratchet tooth is numbered to enable the plunger to be used as a scale. Measurement is effected by placing the sphere on the work to be gauged and raising the external casing, thus compressing the spring and drawing out the plunger. When the constraint of the spring equals the adhesion of the sphere, separation from the work occurs. The plunger is, however, retained in its extended position by means of a light spring pawl and serves to indicate the value of the adhesion. A selection of spheres having different intensities of magnetization is supplied with the instrument to cover the range of coating thicknesses up to 0·5 mm. The accuracy obtainable is within 10 per cent.

In use, the sphere is applied lightly to the material to be measured. In the case of foils, they are placed on a polished steel surface. Force sufficient to make an indentation in the coating should not be used as it may affect the adhesion. The casing is then lifted vertically until the sphere is pulled off the material. This operation is repeated, without resetting the instrument and the highest reading is taken as the correct value. At the moment of separation the pressure of the sphere on the surface of the work is zero and normally cannot influence the reading. Selection of the sphere to be employed is so made that the plunger extension obtained lies between No. 5 and No. 20 of the scale divisions. The sensitivity of the instrument decreases for readings below No. 5, owing to the characteristics of the spring.

A direct calibration of the instrument in thickness measurements cannot be made since the readings depend upon the following factors:

(a) Thickness of the base (if less then 0·4 mm);
(b) Permeability of the base (this has a noticeable influence only with large permeability differences);
(c) Surface roughness (if this is comparable with the coating thickness);
(d) Shape of the work (if the surface has small convex or concave curvatures);
(e) Direction of pull (vertical, from above or below, or horizontal).

The calibration must, therefore, be made by the user to suit the specific conditions obtaining for a particular workpiece or specimen. Any of the following methods may be used for this purpose:

(1) By taking measurements on specimens of known coating thickness.

(2) If specimens without coatings are available the reading corresponding to the desired coating thickness may be determined by adding foils of known thickness.

(3) If it is desired to measure work already coated to an unknown thickness, calibration experiments may be made on a specimen of the same material and shape. Should the base material be less than 0·4 mm, the thickness of the test specimen should be identical with the original. Calibration may, in some instances, be made on the original specimen by using test foils on an area free of coating; possibly on the reverse side.

Sigmagauge "L"

The apparatus is designed specifically to measure the thickness of non-conducting, that is non-metallic, layers on a non-ferrous metallic base. Thus layers of paint, lacquer, vitreous enamel, ceramics or plastics, and anodized coatings on light alloys, copper alloys, zinc and its alloys, or austenitic steels can be measured. This equipment is not suitable for the measurement of metallic coatings on non-ferrous bases. It is operated from a 220-volt A.C. supply and is fused for 1 amp. Mains fluctuations of ±20 volts could cause error up to 1 per cent in measurement.

The test head is a very small coil which is energized by a high-frequency oscillator and the associated magnetic field induces eddy currents in the base material. Their reaction on the coil is used to indicate the separation of the probe from the base metal. For the energizing current a frequency is selected so that the conductivity of the base has little influence and the probe is designed so that its separation from the base, by the thickness of the coating, is linearly related to the output of the amplifier and, thus, to the indication on the meter. Measurement can be made on very small areas, either flat or curved, and the meter is scaled for direct reading in thousandths and decimals of thousandths of an inch.

To calibrate the apparatus the test head is placed on the uncoated, non-ferrous base and the instrument needle is zeroed by means of the left-hand control knob. Next, the calibration foil supplied with the apparatus is placed between the base metal and the test head and the needle adjusted to the corresponding scale reading. A number of different ranges can be provided; scales commonly used are 0 to 0·002 in, 0 to 0·008 in and 0 to 0·020 in. Accuracy of indication is within ±1 per cent.

Another version of this apparatus, designated Sigmagauge "S," is available for the measurement of coatings of high-conductivity, non-ferrous metals on bases of non-ferromagnetic metals of low conductivity. This equipment is used to measure various metal platings on brass, bronze and austenitic steels. An interesting application is the gauging of silver flashings on bronze bearing shells.

Sigmagauge "L" measures non-conducting layers on non-ferrous bases

Magnagauge "L"

Closely resembling the Sigmagauge in external appearance, the Magnagauge "L" measures the thickness of non-ferromagnetic layers on ferromagnetic bases. Thus non-ferrous metal plating, including hard chrome, galvanizing, cadmium or copper, can be measured and also paint, lacquer, or enamel coatings. Nickel on steel cannot be gauged with this instrument.

In this case the test head is a very small magnetic yoke with primary and secondary windings. If the open yoke is brought close to a steel sheet the voltage in the secondary winding will increase because of the reduction in demagnetizing effect and this voltage will reach its maximum when the head is in contact with the steel. The voltage in the secondary winding is, therefore, a function of the distance between the base metal and the test head and can thus be used to measure the thickness of any intervening plating layer.

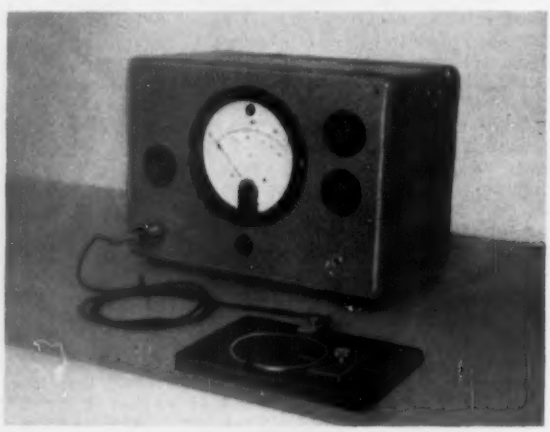
This secondary voltage is fed into a bridge circuit and is initially balanced for an unplated specimen. Out-of-balance voltages caused by the separation of the head from the base are amplified and fed to a large meter scaled directly in layer thickness values.

Calibration is effected by placing the test head on the unplated ferromagnetic base and zeroing the instrument needle with the left-hand control knob. The appropriate calibration foils, supplied with the apparatus, are inserted between the head and the specimen and the needle is set to the scale reading with the right hand control knob. A final re-check of zero is made before measurements are undertaken.

As standard, two scales are provided for a full range coverage, reading 0 to 0·002 in and 0·002 in to 0·012 in, but other ranges can be supplied to specific requirements. If necessary, the range 0·002 in to 0·012 in can be used as 0·004 in to 0·024 in by the use of double calibration foils and adjustment of the calibration control. The scale readings obtained under such conditions must, of course, be doubled. Measurement is accurate to within 2 per cent of the full scale deflection of the meter.

For the measurement of very narrow specimens a special test head is available for this apparatus. An illustration shows it in use for measuring the

Magnagauge "L" instrument for non-magnetic coatings on steel or iron



Magnagauge "L" with special test head for measuring chrome plating on piston rings

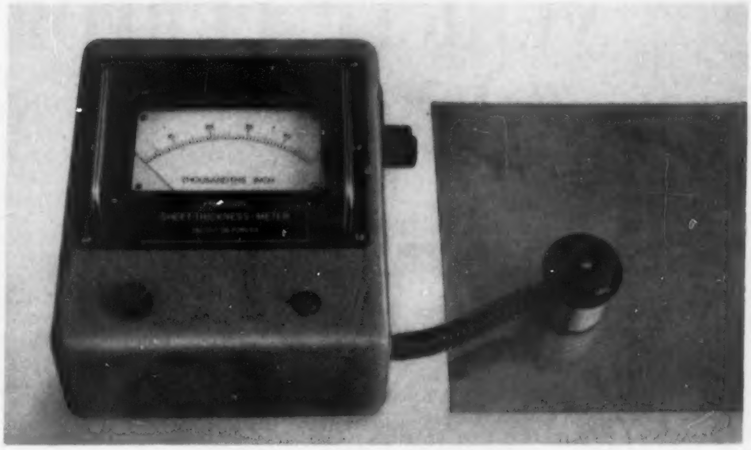
thickness of the chrome layers on piston rings. Another instrument, Magnagauge "N," is specifically designed to measure magnetic layers on non-ferrous bases. Its principal field of application is for coatings of nickel on brass, bronze, or zinc alloys.

Precision sheet thickness meter

In pressing operations it is important that sheet thickness should be consistent and within the predetermined tolerance in order to ensure the quality of the work and to minimize wear in, or possible damage to, the press tools. Uniformity of thickness in an individual sheet is of greater significance than uniformity between one sheet and another, since a sheet having substantial local variations of thickness may behave in the press no better than a sheet of a material possessing poor deep-drawing properties. A micrometer or caliper can be used for spot measurement, but the method is too slow for continuous use in production and, if the sheets are relatively large, the yoke frame is necessarily heavy and cumbersome. An electrical method in which a direct current is passed through the sheet and the voltage drop is measured is also used. It is, however, prone to suffer from temperature variation (a temperature change of 10 deg C can produce an error of 4 per cent in the thickness measurement) and also from edge effect.

The Precision Thickness Meter, as mentioned earlier, is somewhat similar to the Magnagauge instrument, but the magnetic field is produced by a permanent magnet instead of an electro-magnet. It is intended for the unilateral determination of sheet thickness with extreme rapidity and can be applied to industrial operations in continuous production. When the small probe is placed on the sheet, the thickness immediately below the probe is indicated on the meter in 0·10 sec. The large precision scale is calibrated in absolute thickness values and the error of measurement is less than 1 per cent of the total scale. If necessary, readings can be taken at the rate of two per second.

Weighing 12 lb. only, the apparatus is easily transportable. Neither a mains supply nor heavy accumulators are required and a pocket torch dry cell is all that is necessary. The current drain on this cell is less than 0·05 mA and the voltage of the cell does not affect the meter reading in any way. Even with regular use each working day the battery should be good for one year's operation. Connection between the probe and the meter is by a spiralled cable which can be extended to considerable length and automatically retracts to the instrument case after use. The probe is not affected by temperature changes in the material, nor is it susceptible to edge effect. In fact, when the probe is placed on the extreme edge of the sheet the error introduced is less than 1 per cent.



Precision sheet thickness gauge

Where sheets having substantially different saturation magnetization, silicon steel sheets, for instance, are to be measured for their precise thickness, the change in saturation magnetization can be compensated for by means of the calibration control of the apparatus. It is merely necessary to make one calibration reading on a sheet of known thickness. Once calibrated in this manner, the meter will indicate correct thicknesses for this material over the whole range of measurement. Conversely, the adjustment of the calibration control can be used to indicate the character of the alloy steel under test. For example, in a sheet material containing 1 per cent silicon the saturation magnetization is reduced by 480 Gauss. No readjustment of calibration is necessary for sheets of ordinary deep-drawing quality.

The instrument can readily be used for the mass sorting of sheets. For this purpose the probe is built into a stacking table so that it projects from the surface by about 0·020 in. A sheet has to lie on the table for a fraction of a second only for the exact thickness reading to be obtained, irrespective of the area of the sheet. Alternatively, as the probe is small and light, it can be attached to a glove in such a manner that gauging is carried out as part of the stacking process.

It can be mounted on presses, stamps or guillotines, so that a continuous check on the sheet thickness is made during operations on those machines. A probe fitted with rollers can be run over sheets of large area or can be mounted over a conveyor belt for a rapid semi-automatic or fully automatic checking or sorting of sheets.

As an instrument for measuring coating thickness, the Precision Thickness Meter is suitable for non-magnetic layers, for example, bitumen, paint or plastics, on bases of iron or steel. The operative range is from 0·025 in to 0·150 in and it is applicable to either flat or curved surfaces. For this purpose, the accuracy is within ±1 per cent.

MECHANICAL HANDLING

A FILM entitled "Mechanical Handling on Show" can be obtained on loan from *Mechnical Handling*, Dorset House, Stamford Street, London, S.E.1. It is particularly suitable for showing to potential overseas buyers of mechanical handling equipment as well as professional and technical organizations, trade associations, engineering training colleges, industrial chambers of commerce, works management committees and, in fact, manufacturing and industrial firms in general. This 16 mm colour film with sound commentary has a running time of approximately 30 min. The object of the film is to provide a pictorial record of some of the main exhibits at the Mechanical Handling Exhibition, which is held in London every two years. The next exhibition will be held in 1956.

This exhibition is the largest display of labour-aiding equipment held in the world, and the film depicts one or more examples of each of the various classes of mechanical handling equipment. It thus forms an introduction to all the principal types of equipment that are manufactured by British firms. The commentary gives information on the general operational features of the equipment and the classes of goods they are designed to handle.

The film has been sponsored by our associated journal *Mechnical Handling*. It is produced by John Byrd Film Productions and the commentary is spoken by Frank Phillips, the well known B.B.C. commentator.

VEHICLE PERFORMANCE

The Effect of Rotating Masses on Acceleration

J. L. Koffman, Dipl.-Ing., M.I.Loco.E.

When a vehicle is accelerated, the power developed by the engine is used to overcome the tractive resistance as well as to accelerate the mass of the vehicle. Moreover, energy is absorbed not only in accelerating the vehicle linearly but also in overcoming the inertia of the rotating masses, such as the wheels, shafts and transmission components, and the engine with its flywheel and clutch. The rotational inertia can be considerable, particularly in high gears. Hitherto, because of the scarcity of data available, this has not always been fully appreciated.

From Newton's Second Law of Motion,

$$M\frac{d^2s}{dt^2}=F-R$$

where s is the displacement of the vehicle along a straight line, F the resultant of all the propelling forces and R the resultant of all the resistance forces. When dealing with vehicles, since they incorporate rotating components, the equation of motion can be best evolved from the theorem of kinetic energy, in accordance with which the increment of kinetic energy dK of any system is equal to the corresponding work produced by the external forces applied to it. For the simplest case of rectilinear motion of a car the elementary change of energy dE in time dt on a distance ds is:

$$dE=Mvdv$$
$$=(T-R)ds$$

where v is the momentary speed and dv the differential of speed. When there are rotating components, the value of dK is given by:

$$K=\frac{Mv^2}{2}+\sum\frac{I\omega^2}{2}$$

where $v=ds/dt$ is the speed of the forward motion, I the polar moment of inertia of each rotating component, and ω its angular velocity.

Differentiating this equation, where M and I are constant,

$$dK=Mvdv+I\omega d\omega$$

but in accordance with the theorem of kinetic energy

$$dK=dE$$

consequently,

$$M\frac{dv}{ds}\frac{ds}{dt}+\sum I\omega\frac{d\omega}{ds}=F-R$$

or

$$(1+\gamma)\,M\frac{dv}{dt}=F-R$$

where

$$\gamma=\frac{\sum I\frac{\omega}{v}\frac{d\omega}{dv}}{M}$$

is a dimensionless quantity that represents the effect of the rotating masses. Thus, the mass of a car M is considered as being concentrated at its centre of gravity and supplemented by a certain quantity γM. The mass,

$$M'=(1+\gamma)\,M$$

is referred to as effective, equivalent or accelerating mass.

It is of interest to note that in accordance with the theory of relativity, for the motion of a particle

$$K=\tfrac{1}{2}Mv^2+\tfrac{3}{8}M\frac{v^4}{c^2}+\dots\dots\dots$$

where $c\approx 187{,}000$ miles/sec, which is the speed of light. Even with the highest vehicle speeds attainable at present, the value of the second term is entirely negligible, so the Newtonian mechanics is quite satisfactory for even the most modern forms of transport.

In the case of an automobile,

$$K=\frac{Mv^2}{2}+\frac{I_f\omega_f^2}{2}+\sum\frac{I_w\omega_w^2}{2}$$

where $M=W/g$ is the mass of the complete vehicle, W its weight, g the gravitational constant, v vehicle speed, I_f the polar moment of inertia of the engine flywheel, crankshaft, and connecting rods and piston assembly referred to the effective crankshaft radius, ω_f the angular velocity of the flywheel and I_w and ω_w the polar moment of inertia and rotational speed of the road wheels. If the polar moments of inertia of all wheels are equal, the summation sign in the last component can be replaced by the number of wheels n. Because the inertias of transmission components are relatively small they can be neglected. If the wheels rotate without slipping,

$$v=\omega_w r=\frac{\omega_f}{i_g\,i_a}r$$

where r is the rolling radius, i_g the gearbox ratio and i_a the final drive ratio. Therefore,

$$\omega_w=\frac{v}{r}\text{ and }\omega_f=\left(\frac{v}{r}\right)i_g\,i_a$$

Thus, the equation of kinetic energy can be rewritten,

$$K=\frac{Wv^2}{2g}+\frac{I_f v^2(i_g\,i_a)^2}{2r^2}+\sum\frac{I_w v^2}{2r^2}$$

Differentiating this equation,

$$dK=vdv\left[\frac{W}{g}+\frac{I_f(i_g\,i_a)^2}{r^2}+\sum\frac{I_w}{r^2}\right]$$
$$=\left[(F-R)+I_f\frac{d\omega_f}{dt}\frac{i_g\,i_a}{r}(1-\eta_m)\right]ds$$

where η_m is the overall transmission efficiency. But since

$$v=\frac{ds}{dt}\text{ and }\frac{d\omega_f}{dt}=\frac{dv}{dt}\frac{i_g\,i_a}{r}$$

the following equation will apply:

$$\frac{dv}{dt}=\frac{T-R}{\frac{W}{g}-\frac{I_f\,(i_g\,i_a)^2}{r^2}\eta_m+\sum\frac{I_w}{r^2}}$$

The mass of the flywheel relative to the vehicle mass is determined from:

$$\frac{I_f\,(i_g\,i_a)^2}{r^2}\eta_m=\alpha\frac{W}{g}$$

whilst that of the wheels is:

$$\sum\frac{I_w}{r^2}=\beta\frac{W}{g}$$

Therefore,

$$\frac{dv}{dt}=\frac{T-R}{\frac{W}{g}\,(1+\alpha+\beta)}$$

and if $\gamma=\alpha+\beta$,

$$\frac{dv}{dt}=\frac{T-R}{M(1+\gamma)}$$

Although the moment of inertia of the flywheel can be determined analytically without much difficulty the determination of that of the crankshaft[1] and connecting rods is more complicated, though recourse can be taken to simple experimental methods. For the road wheels, it is advisable to determine the

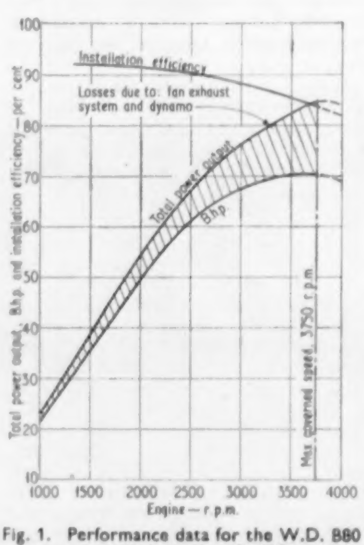


Fig. 1. Performance data for the W.D. B80 engine as installed in the FV 1800 vehicle

value of I_w experimentally. The value of β for a total of eleven vehicles ranging from four-passenger cars to six-wheel trucks weighing over 10 tons fully laden, was found to vary between 0·037 and 0·0483, and the average value was $\beta=0{\cdot}04$.

The value of α depends upon I_f as well as $(i_g\, i_a)^2$, which can attain very high values, particularly with heavy trucks with two-speed auxiliary boxes. The moment of inertia of the engine is relatively small, amounting to about 10 to 15 per cent of the inertia of the wheels. On the other hand, some 80 to 90 per cent of the total is due to the flywheel and clutch. However, it is when multiplied by $(i_g\, i_a)^2/r^2$ that the full significance of α is realized; in fact, α may be as high as 6·5 for fully laden lorries in high gear and in the high ratio of a two-speed auxiliary box. Axle ratios are rarely less than 4·2 or more than 7·7 and are generally between 4·5 to 6·5, heavy vehicles having ratios of about 6. Therefore, the values of i_a need not be taken into consideration so far as the determination of α and γ are concerned; γ is obtained from

$$\gamma = 0{\cdot}04 + 0{\cdot}05\, i_g^{\,2}$$

This equation has been derived from an analysis of a considerable number of vehicles and refers to fully laden conditions.

These equations are based on absolute units of feet, pounds, and seconds. For units that are generally in use for the expression of vehicle performance, capital letters are used; thus, if V is in m.p.h., $V=(3{,}600/5{,}280)v=v/1{\cdot}467$, where v is in ft/sec. If acceleration is in miles per hour per second, $A=(1/1{\cdot}467)a$, where a is in ft/sec²; and for mass, $M=(32{\cdot}17/2{,}240)=1/69{\cdot}5$ tons weight. The constant $C=(1/69{\cdot}5)\,(1/467)=1/102$ must be used if v is in m.p.h., t in seconds, dV/dt in miles per hour per second, $(T-R)$ in lb weight and W in tons weight. Thus,

$$A = \frac{dV}{dt} = \frac{T-R}{102\,(1+\gamma)\,W}$$

$$= \frac{T-R}{102W\,(1{\cdot}04+0{\cdot}05\, i_g^{\,2})}$$

This equation can be rewritten:

$$A = \frac{t-r}{102W\,(1{\cdot}04+0{\cdot}05\, i_g^{\,2})}$$

$$= \frac{b}{102W\,(1{\cdot}04+0{\cdot}05\, i_g^{\,2})}$$

where A is the acceleration in miles per hour per second and t and r are tractive effort and vehicle resistance in pounds per ton weight, whilst b is the excess tractive effort, also in lb/ton, available for acceleration or climbing.

In the course of a general investigation of vehicle performance carried out by the Fighting Vehicles Research and Development Establishment (F.V.R.D.E.) of the Ministry of Supply, the acceleration performance of the FV 1800, 4×4, 5 cwt truck, the military version of the Austin Champ described in the September and October, 1955, issues of *Automobile Engineer*, was extensively investigated. The empty vehicle weighed 3,640 lb, and the laden weight throughout the tests was 2·1 ton. It was powered by a W.D. type B.40, four-cylinder engine of Rolls-Royce design, the output of which is plotted in Fig. 1. The vehicle had covered some 1,300 miles before the tests were carried out. For the tests, the vehicle was accelerated, with rear-wheel drive only engaged.

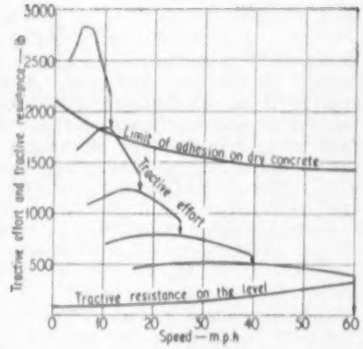


Fig. 3. Tractive effort and resistance of the FV 1800 vehicle

A fifth wheel, actuating micro-switches connected to a Kelvin and Hughes single pen recorder, was employed to take the time-distance measurements on the straight and level portion of the F.V.R.D.E. track. The recorder and fifth wheel speeds were previously calibrated so that the distance along the paper record represented time, and road distance was indicated by the marks made by the pen. To ensure accuracy of evaluation, a procedure suggested by Sauer and Pösch[3] was employed. This procedure is based on the method of least squares and thus smooths out irregularities in the original determinations.

With this procedure, the time data is divided into small equal steps $s=\Delta t$. The corresponding values of t sec are entered in the first column of Table I, which illustrates the procedure, while the distance Δ_{-1} covered during the interval X_{-1} to X_0 is entered in the second column half-way between these two values of X. The difference values Δ^2 and Δ^3 are obtained by subtracting the lower value from the higher one in each pair, so $\Delta^1{}_0=X_1-X_0$, $\Delta^2{}_{-1}=\Delta^1{}_0-\Delta^1{}_{-1}$ and $\Delta^3{}_{-1}=\Delta^2{}_0-\Delta^2{}_{-1}$, etc. From this, the mean speed for the time interval is given by:

TABLE I.

1	2	3	4	5
X_{-2}				
	$\Delta^1{}_{-2}$			
X_{-1}		$\Delta^2{}_{-2}$		
	$\Delta^1{}_{-1}$		$\Delta^3{}_{-2}$	
X_0		$\Delta^2{}_{-1}$		$\Delta^4{}_{-2}$
	$\Delta^1{}_0$		$\Delta^3{}_{-1}$	
X_1		$\Delta^2{}_0$		
	$\Delta^1{}_1$			
X_2				

$$V = \frac{ds}{dt}$$

$$= \frac{1}{2\Delta t}(\Delta^1{}_{-1}+\Delta^1{}_0)+\frac{1}{5\Delta t}(\Delta^3{}_{-2}+\Delta^3{}_{-1})$$

To illustrate the method further, some of the time-distance values obtained during these tests, and their evaluation in terms of speed, are shown in Table II. The results for rear-wheel drive only are plotted in Fig. 2.

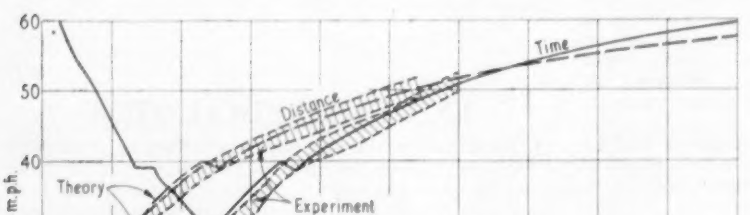


Fig. 2. Acceleration of the FV 1800 vehicle on a level concrete road

For an analysis of vehicle acceleration it is necessary to know the tractive resistance. For the FV 1800 in rear-wheel drive, this was determined from track

tests, which showed it to be

$$R = W(35+0{\cdot}25V)+C_d \times 0{\cdot}26 \times A'(V/10)^2$$

lb where W is the vehicle weight in tons, V the speed in m.p.h., C_d the drag coefficient, A' the projected frontal area in ft^2; in this instance $A'=26$ ft^2. For FV 1800, the value of the drag coefficient was found to be 0·95, a somewhat high value for this type of vehicle, although the figure cannot be claimed to be absolutely accurate. The constant 0·26 is introduced since A' is in ft^2 and V in m.p.h.; it applies for air at N.T.P., for which the density is 0·002378 lb-sec^2/ft^4. Thus $0{\cdot}002378/(2\times 1/1{\cdot}467^2)=0{\cdot}00256\approx 0{\cdot}26\,(1/10)^2$. The tractive effort of the vehicle is calculated on the basis of the installed power output of Fig. 1 and assuming an overall transmission efficiency of 90 per cent, and the results are plotted in Fig. 3. Since the tractive effort T, resistance R and the excess tractive effort $b=t-r$ in lb/ton are known, it is possible to determine the acceleration from $A=b/[102\,(1+\gamma)]$, and from this, since $dt=dV/A$, the time increment dt for each velocity increment dV can be obtained. The distance increment ds, in ft, is $ds=dt\times V_m\times 1{\cdot}467$, where V is the mean velocity in m.p.h. throughout each time increment.

The polar moment of inertia of each wheel was found experimentally to be 18 lb-in-sec^2 which, with a wheel radius of 14·4 in, gives $\beta=0{\cdot}04$. For the engine and flywheel, $I_f=5{\cdot}45$ lb-in-sec^2, so that for the gears from first to fifth, $\gamma=1{\cdot}54$, 1·67, 1·32, 1·156 and 1·09 respectively. The acceleration data thus obtained, with an overall transmission efficiency of 90 per cent and a 1 sec allowance for each gear change, are plotted in Fig. 2.

TABLE II.

t (sec)	Δ ft	Δ^1	Δ^2	Δ^3	V (ft/sec)
1	6·3				
		11·3			
2	17·6		5·5		
		16·8		4·6	
3	34·4		0·9		16·55
		17·7		1·5	
4	52·1		2·4		19·74
		20·1		2·7	
5	72·2		5·1		
		25·2			
6	97·4				

A considerable number of tests were carried out in each direction on the track and the results for speeds of up to 50 m.p.h. are also plotted in Fig. 2. According to the tests, a speed of 50 m.p.h. is attained in 27·5 to 30 sec, whereas the calculated value is 28·7 sec. Also, the experimentally determined distance is 1,220 to 1,400 ft, as compared with the calculated value of 1,350 ft. The differences are due to the fact that it is impossible to maintain ideal conditions on a test track, because of differences in engine power output and the actual time taken to change gear. However, the agreement between the theoretical and actual values is considered as satisfactory.

It is of interest to note that if γ is assumed to be 0·05 throughout the entire speed range, the results are as shown in Table III. Although the difference between columns 2 and 4 is relatively large, for the first and second gear, it is not exceptionally so for a vehicle of high power/weight ratio powered by a high-speed engine, that is, where I_f is small. With vehicles having a less favourable power/weight ratio and powered by slower engines the divergence might be considerable; therefore, unless the actual values of α and β are available, the empirical equation for γ should be used for the determination of acceleration.

TABLE III.

	$\gamma=0{\cdot}05=$ Constant		$\gamma=0{\cdot}04+0{\cdot}05i^2_g$	
	Time, sec	**Distance, ft**	**Time, sec**	**Distance, ft**
1st gear	0·8	7·8	2·0	18·0
2nd gear	2·7	43·5	4·7	67·5
3rd gear	6·2	140·5	8·8	184·0
4th gear	14·0	505·0	17·3	578·0
5th gear	47·0	3,000·0	51·0	3,150·0

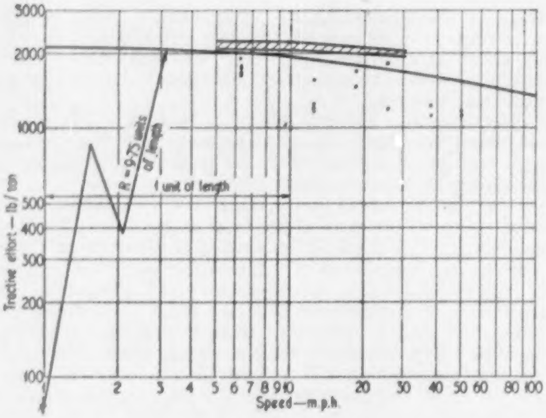


Fig. 4. Adhesion on a dry concrete road

The author is indebted to A. V. Carter, B.Sc., and D. Pooley, who carried out the vehicle acceleration tests and analyzed the results.

References

1. H. SCHRÖN: "Die Dynamik der Verbrennungskraftmaschine," *Springer-Verlag*, Vienna, 1947.
2. R. SAUER and H. PÖSCH: "Rechnerische Differentiation von Kurven," Z.VDI., Vol. 85, No. 8, 22nd February, 1941.

Appendix

As indicated in Fig. 3, the tractive effort available in bottom gear exceeds the limit of adhesion between the tyres and the road. Although the coefficient of adhesion depends on tyre pressure, wheel load, type and condition of road and tyres, and on vehicle speed which, being perhaps the most important, is the only one that will be considered here.

Some of the data published during the last twenty-five years for adhesion on dry concrete roads are plotted on log-log scales in Fig. 4. The limit is represented by the arc of a circle the equation of which is:

$$(\text{Log } V)^2+(\text{Log } T)^2=95$$

where V is in m.p.h., and T the tractive effort in lb/ton. The final equation, which represents a hyperbola with co-ordinates through the point of origin is:

$$T\ (\text{lb/ton})=\frac{20{,}000}{V+20}+1{,}250$$

EXIDE TECHNICAL FILM

A NEW mobile film unit has been formed to give a show entitled "Under Your Bonnet" to gatherings of the motor trade all over the country. This film, which has been sponsored by Chloride Batteries Ltd., shows how Exide batteries are made. Not only is the photography good and the film most informative from the technical point of view, but also it is both interesting and entertaining.

The film begins with some brief illustrations of the history of the development of the modern car battery and then shows the dangers of employing cheap, unbranded batteries instead of a high quality product of an established, reputable manufacturer. Next, the various stages in the production of Exide batteries are shown and described. In these scenes, the manufacture of the grids, pasting and drying, are first shown. Then the plates are passed to the forming department, where they are immersed in tanks and current is passed through them to activate the paste. Other scenes show Porvic being made, and the manufacture, assembly, testing and inspection of all the components.

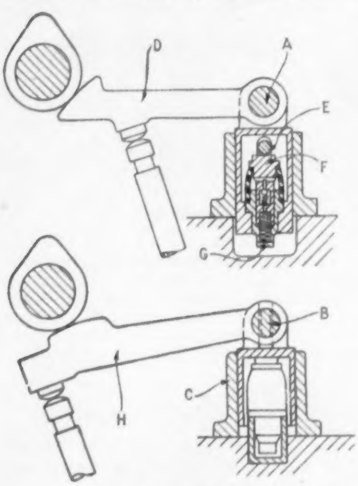
CURRENT PATENTS

A Review of Recent Automobile Specifications

Automatic adjustment of valve clearance

IN an engine of the inclined overhead valve type the valves are actuated by an overhead camshaft through interposed rocker levers. Control of valve clearance is effected by hydraulic devices which automatically adjust the height of the lever fulcra relative to the valve seats. The point of application of one lever to its respective valve stem is within the distance from the fulcrum to the camshaft, while on the other lever it is beyond the camshaft. To take up clearance, therefore, it is necessary to lower the fulcrum in one instance and to raise it in the other.

Fulcrum pins A and B are adjustably mounted side-by-side in a common housing C secured to the cylinder head. Fulcrum A carrying lever D is drawn down by a one-way hydraulic adjuster F



No. 726505

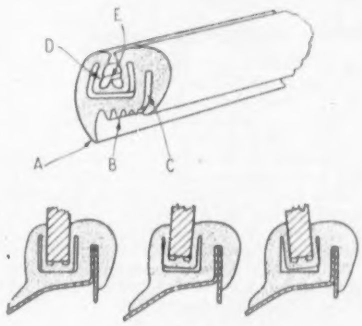
of known type. The ram of this device bears against a cross pin E in the housing C and the cylinder part displaces the fulcrum mounting downwards by means of the spring G.

A similar device is used for fulcrum B of lever H, but in that instance the cylinder part is seated in a cup in the cylinder head and the ram directly displaces the fulcrum mounting upwards.

It is of advantage to retain the levers in their prescribed planes of oscillation. This is effected by the cross pin F in the case of lever D and by the tongued end of fulcrum B slidably engaged in a fork on housing C for lever H. *Patent No.* 726505. *Daimler-Benz A.G. (Germany).*

Sealing curved screens or windows

THE curved windscreens and curved rear windows increasingly featured in car bodies are difficult to produce to exact dimensions. Wide assembling tolerances are necessary and imperfect weather-sealing may result when known types of resilient beading strip are used. Designed specifically for the purpose, this beading



No. 726023

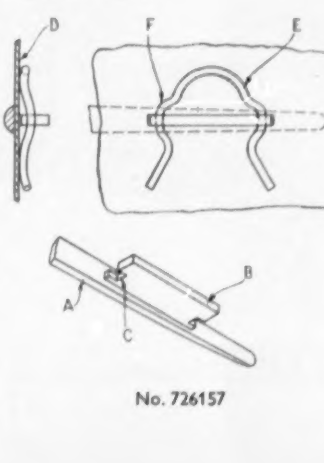
strip is claimed to accommodate dimensional inaccuracy and give unimpaired weather-sealing.

Of rubber or rubber-like material, the strip has a sealing lip A at one side and a plurality of sealing ribs B on the outer face to engage the body panel. In the same face is a continuous slot C to receive the body panel flange. The channel in the inner face is formed with a re-entrant pocket D to receive the glass light. On assembly the light compresses the sealing rib E in the base of the pocket, which can be displaced bodily in the channel.

From the sectioned views of the strip installed it will be seen that displacement of lip A and the lip of slot C causes the margins of the channel to grip the light while the pocket D deforms to accommodate dimensional inaccuracy or misalignment. *Patent No.* 726023. *General Motors Corporation (U.S.A.).*

Tongue and slot fastening

POLISHED metal motifs, flashes or finishers used to embellish the bodywork of modern vehicles are likely at some points to be so narrow and shallow in cross section that it is not practical to incorporate integral studs for fixing purposes. To obviate this difficulty the embellishment is formed with a narrow tongue which is inserted in a slot in the panelling and resiliently secured by a spring wire clip.

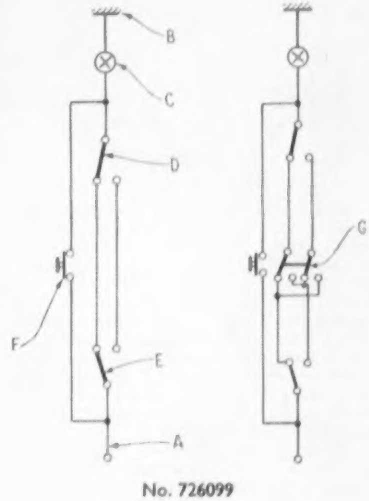


No. 726157

In the example shown, a flash A is provided on the back with an integral tongue B having at each end a notch C. The tongue is passed through a slot in the body panel D and a straddle clip E is pushed into position, from either side, until the curved parts F of the limbs snap into notches C. As the limbs are bowed in way of the curved parts F the flash is drawn tightly against the outer face of the body panel. *Patent No.* 726157. *Morris Motors Ltd.*

Interior light switching

WITH a common type of switching circuit the interior lighting is switched on by opening the vehicle doors and additionally can be operated by a switch on the instrument panel or on a door post. In use, however, certain shortcomings are disclosed. To switch off automatically immediately the door is closed may be too



No. 726099

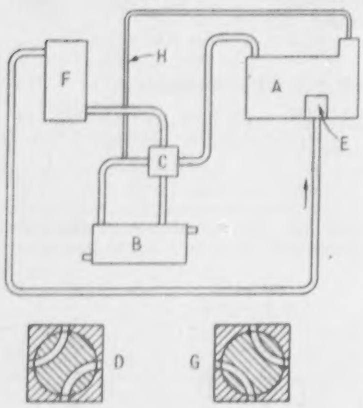
soon for convenience and to leave the door open until passengers are seated may be undesirable. The addition of simple on-off switches connected in parallel offers only a partial solution and is inconvenient inasmuch as the lighting must necessarily be switched off at the point it was switched on.

To overcome these disadvantages the circuit from supply lead A to chassis earth B for interior light C includes two single-pole, two-way switches D and E. A door-switch circuit connected in parallel includes at least one switch F arranged to close or open by respectively opening or closing the door. Where two or more door switches are included they are connected in parallel.

If desired the circuit can be extended for manual control at one or more additional points by the inclusion of double-pole, two-way switches, as at G, in the selectable conductors between the single-pole switches D and E. *Patent No.* 726099. *Bayerische Motoren Werke A.G. (Germany).*

Heating system

A DRAWBACK of the conventional car heater deriving its heat from the engine coolant system is the lengthy period that must elapse before adequate heat can be obtained from the cooling medium after a start from cold. Heaters utilizing the exhaust system as a heat source are more rapidly responsive but are not favoured owing to the hazard of corrosion and possible gas leakage. Neither arrangement aids the engine to warm up quickly. The invention employs both exhaust gas and engine coolant heat exchangers in series to obviate the disadvantages and also to effect a rapid warm-up of the engine.



No. 726992

On starting up engine A, exhaust gas passes through the gas-water heat exchanger B. Four-way valve C, in the position shown at D, allows water circulated by pump E to flow from engine to exchanger B and thence to water-air heat exchanger F and return to the engine. The engine coolant is rapidly warmed and when the predetermined operating temperature has been attained, the exchanger B is cut out by means of a manual or a thermostatic control which alters valve C to the position shown at G.

Water is then circulated directly from the engine to the exchanger F, and the exchanger B is by-passed. Water confined in exchanger B eventually boils and, as steam, passes by way of a constricted vent pipe H to the engine radiator, where it condenses back to liquid. The existence of the vent H does not materially affect operation when exchanger B is included in the circuit. *Patent No.* 726992. *Thompson Products, Inc. (U.S.A.).*

Interleaved spring assemblies

ACCORDING to this invention, interleaving components for laminated spring assemblies comprise a matrix of metallic or other material of requisite strength with polytetrafluoroethylene incorporated in or bonded to both upper and lower surfaces. In one embodiment the carrier matrix consists of sintered porous copper about 0·020 in thick and having 25 per cent to 30 per cent voids. Polytetrafluoroethylene in the form of foil 0·003 in thick is pressed on to both sides of the matrix at a temperature of 400 deg C, being forced into the surface pores and leaving a surface skin about 0·001 in thick. Under the action of heat and pressure in operation, the p.t.f.e. will exude to form a smear over the surfaces.

In three alternative processes, p.t.f.e. in either foil or powder form is applied to copper carriers of the perforated strip, knurled or pitted strip, and wire gauze types, by stainless steel platens heated to a temperature of 400 deg C and exerting a pressure of 1 ton/in^2. Copper is not essential, however, as a carrier. Steel strip that has been phosphated or otherwise treated to produce a surface texture that is porous or creviced may be used.

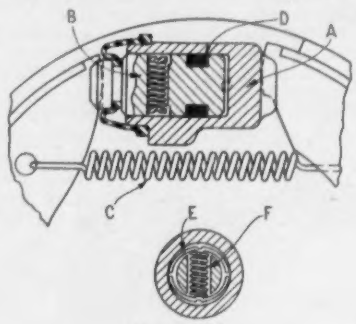
Instead of a metallic matrix, a resin-bonded fabric may be used. Finely powdered p.t.f.e. may be mixed with a synthetic resin powder of the Bakelite type and reinforcing fibres of asbestos, and then moulded under heat and pressure, p.t.f.e. being about 20 per cent of the mixture. *Patent No.* 721949. *Glacier Metal Co. Ltd.*

Automatic brake adjuster

THIS device is suitable for use with either drum or disc brakes and is conveniently allied with hydraulic operating mechanism. It is, however, not limited in that respect and can be embodied in any operating gear having two telescoping elements.

In the drum brake illustrated, the wheel cylinder A is slidably mounted on the backplate and its closed end is slotted to engage one shoe. The projecting end of piston B is slotted to receive the web of the other shoe and both shoes are drawn away from the drum by return springs C. On the piston, between the packing ring D and the projecting end, is formed a circumferential groove and a diametral hole.

Housed in the groove is a pair of arcuate strips E having an internal radius slightly greater than that of the bore of the cylinder and subtending an angle of slightly less than 180 deg. A compression spring F passing through the diametral hole engages dimples on the strips and locates them circumferentially whilst urging them outwards. On application of the brake, the frictional grip of the strips E is insufficient to prevent relative movement of piston and cylinder, but on release they serve as a stop. The return movement of the shoes under the constraint of springs C



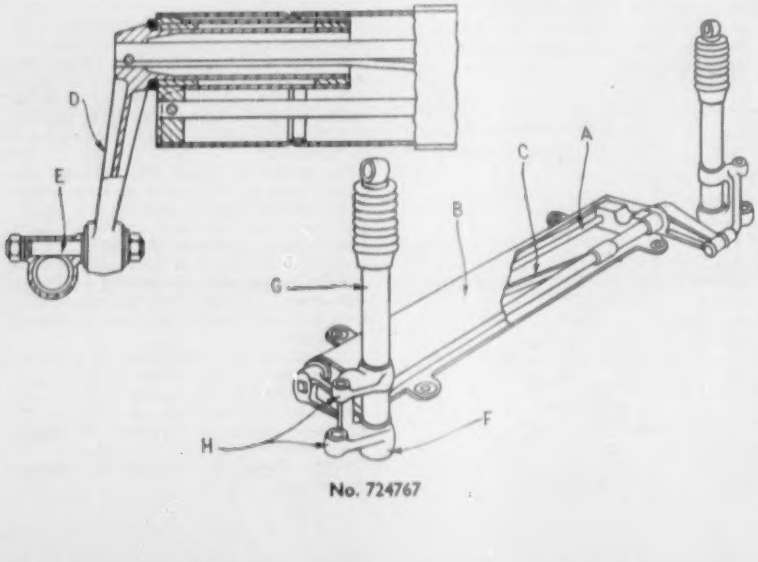
No. 726548

is limited to the predetermined clearance between the strips and the walls of the circumferential groove. Thus the shoes are maintained at a constant distance from the drum, irrespective of lining wear. *Patent No.* 726548. *Automotive Products Co. Ltd.*

Independent front suspension

IN wheel suspension systems of the trailing link type, two superposed arms are commonly used to form a parallelogram for wheel guidance. By this invention only a single arm operating in conjunction with a vertically arranged shock absorber is required. The two torsion bars A, preferably of the laminated bar type, are arranged parallel in a horizontal plane and enclosed in a shallow casing B furnished with lugs for attachment to the vehicle frame or body structure. Occupying the space between the bars A is a third torsion bar C, connecting diagonally the free ends of bars A, and serving as a stabilizer.

Each trailing arm D carries a journal pin E on which the wheel carrier F is pivotally mounted. The carrier forms the bottom closure of the telescopic shock absorber G and is provided with brackets H to receive the swivel pin. Since the bars A are spaced one behind the other and arms D are both of the same length, the swivel pins are brought to the same vertical transverse plane by arranging the pin E forward of the shock absorber axis in one case and to the rear of that axis in the other. The spacing of the torsion bars is twice the offset of the pivot from the shock absorber axis, and thus identical components can be used on both sides of the vehicle. *Patent No.* 724767. *F. Porsche* (Germany).



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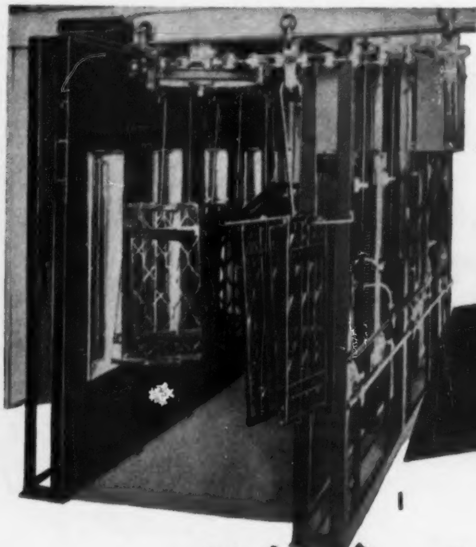

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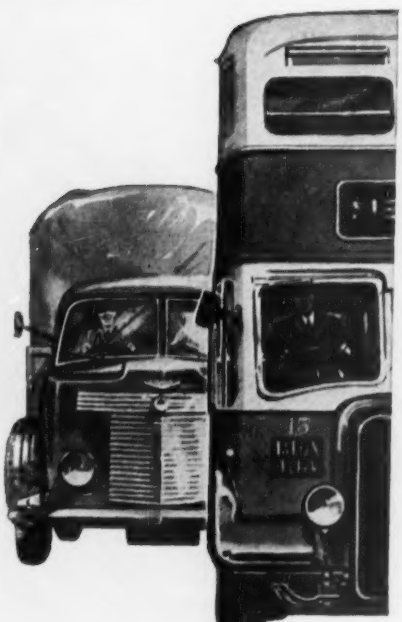

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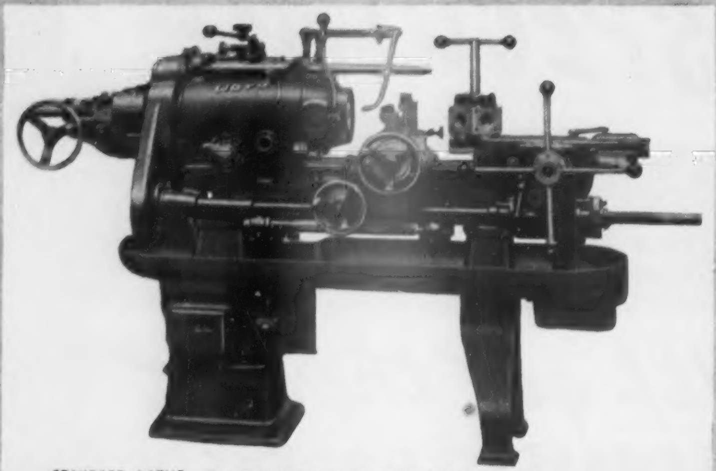

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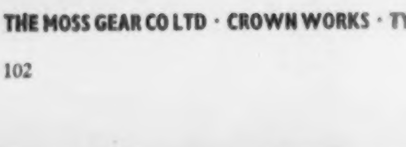

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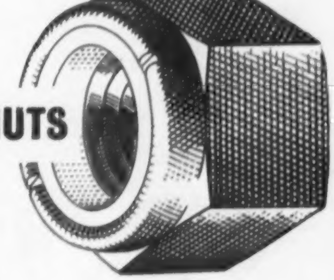

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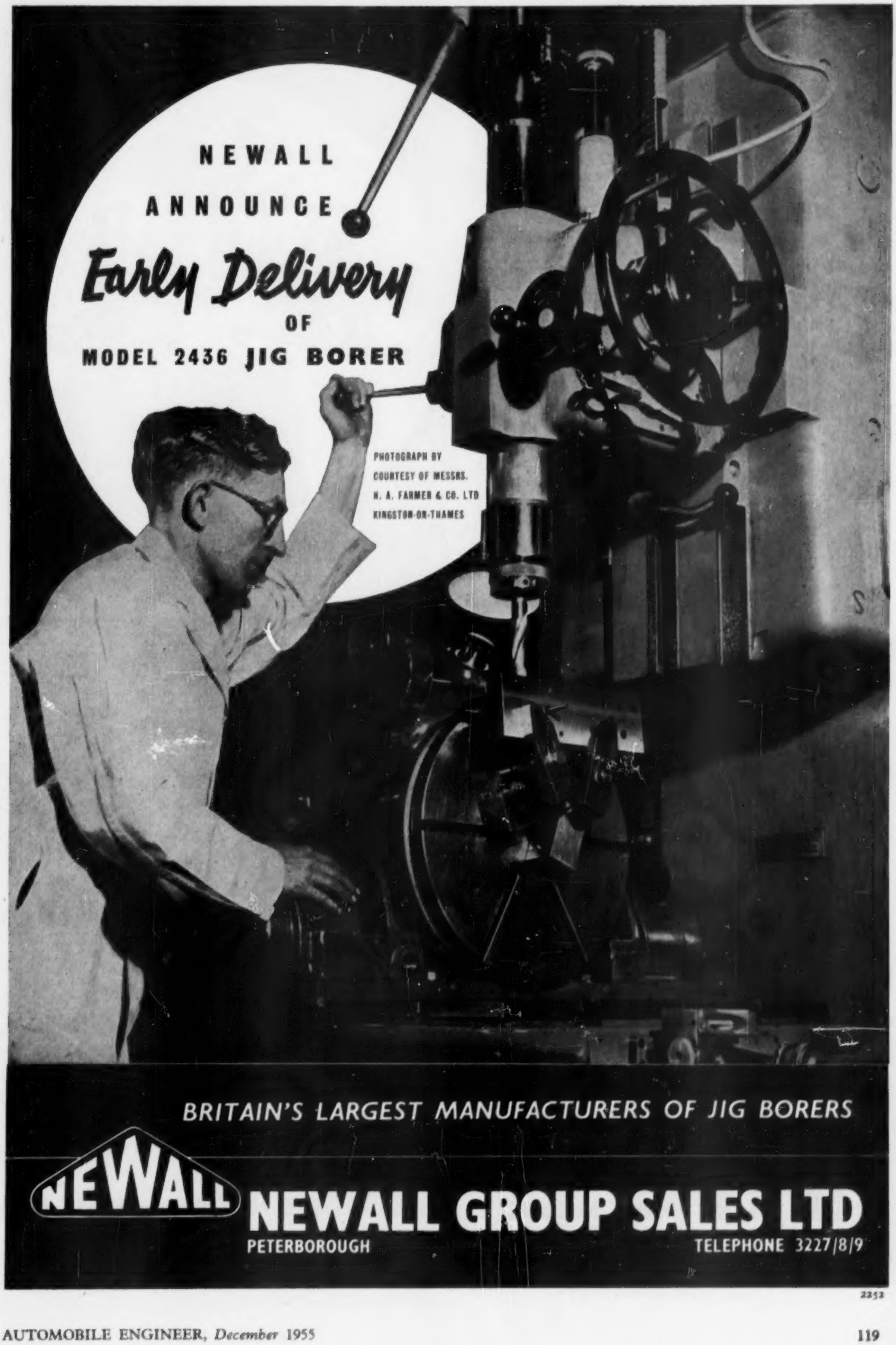
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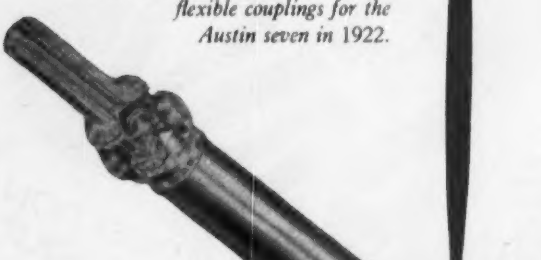

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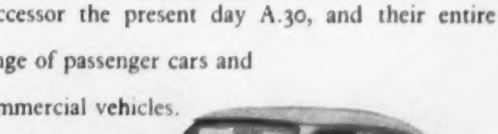

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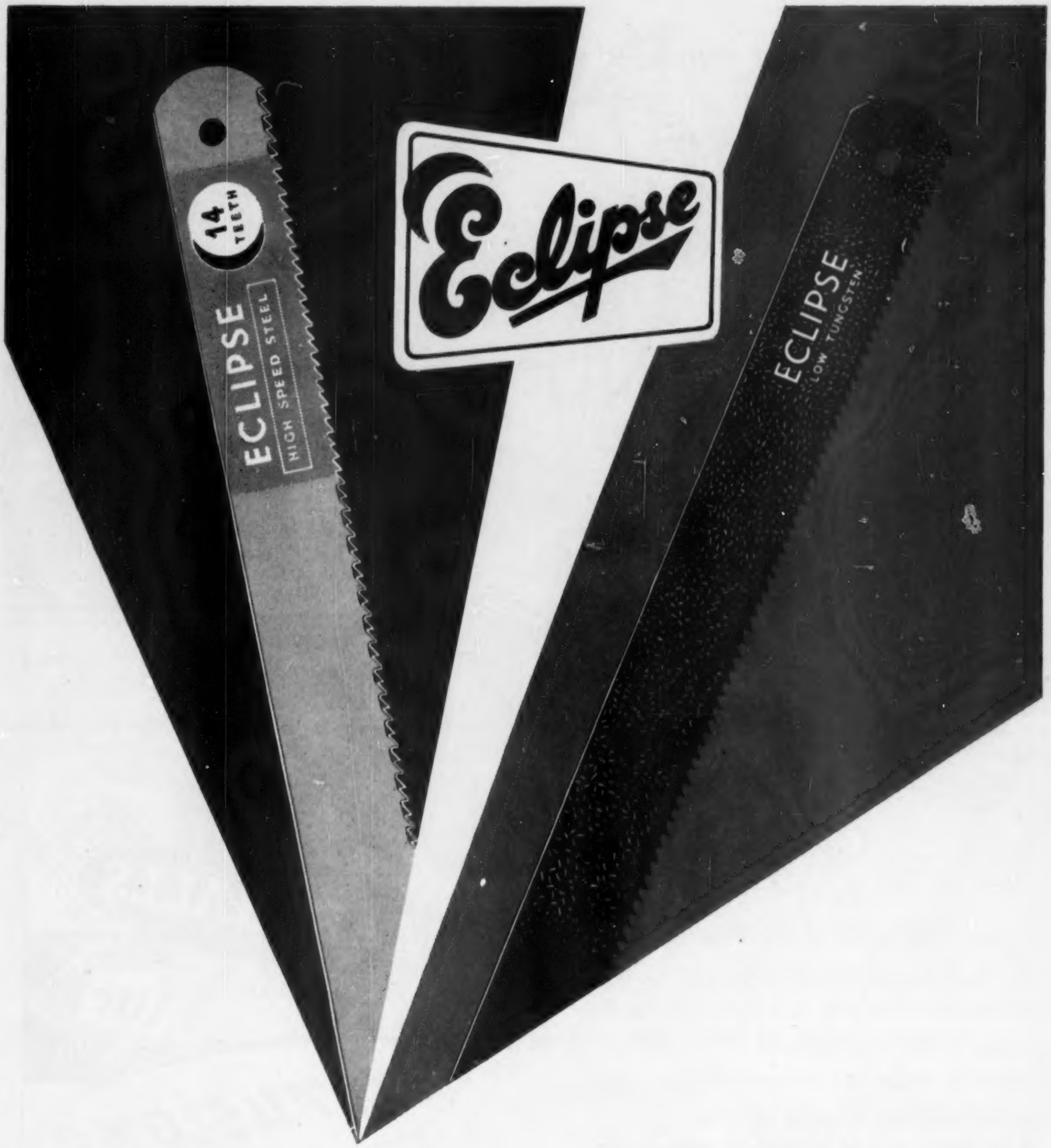
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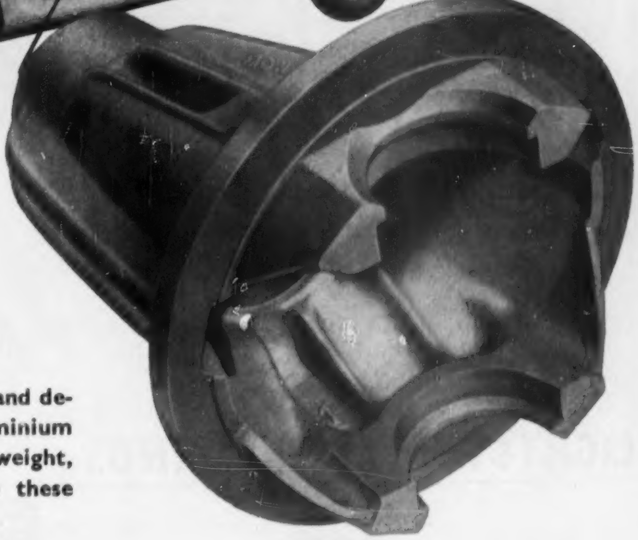

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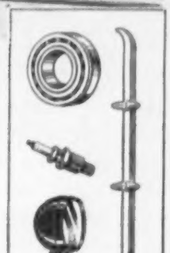

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